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APPLIED MECHANICS REVIEWS

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GENERAL THEORY OF BUCKLING

H. L. LANGHAAR

DEPARTMENT OF THEORETICAL AND APPLIED MECHANICS
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

Various aspects of the theory of buckling are expounded in many treatises (1 to 15). The books of Bleich (2) and Salmon (3) contain large bibliographies. Goodier (16) and Hoff (17) have recently surveyed some of the modern developments in buckling theory. Numerous references are appended to Hoff's article. Nearly all publications on buckling of shells, available in the U.S.A. (to 1956), are listed in the bibliographies on shells by Nash (18). The section "Buckling Problems" in *Applied Mechanics Reviews* is a ready guide to recent literature.

BIFURCATION THEORY

Broadly speaking, the theory of buckling is the theory of stability of equilibrium of mechanical systems. H. Poincaré (19) developed some general theorems on stability of mechanical systems in his study of stability of rotating masses of fluid. He observed that, when the load on a mechanical system increases, the points in a topological configuration space that represent equilibrium states describe certain paths. Usually there is only one path, and it has a single branch, if the load is small. However, "forks" or "bifurcation points" may occur in the path at higher loads. Poincaré assumed that the unbuckled form, represented by the stem of the path, becomes unstable after a bifurcation point is passed. However, as Pflüger (5) has mentioned, not all buckling is of the bifurcation type. For example, if a shallow arch snaps through symmetrically, its representative point in configuration space jumps; there is no fork in the path. Even more remarkable are systems devised by Pflüger (5) and Ziegler (13) which have single paths with no bifurcation points, yet they possess no stable states when certain critical loads are exceeded.

Poincaré discussed conservative mechanical systems with enumerable coordinates $x_1, x_2, \ldots$. The equilibrium configurations are then determined by $\partial V/\partial x_i = 0$, in which V is the total potential energy. Poincaré showed that, when these equations are satisfied, the occurrence of a bifurcation point corresponds to vanishing of the Hessian determinant, det $(\partial^2 V/\partial x_i\, \partial x_j)$.

The bifurcation concept was implicit in Euler's treatment of the column. The equilibrium equation for a slightly deflected column was formulated and, through linearization of the curvature term, a linear eigenvalue problem resulted. The same idea was applied later to beams, arches, plates, and shells by innumerable investigators. The eigenvalue approach to a buckling problem via the equilibrium equations for the slightly buckled structure is called the "equilibrium method" or the "statical method."

ENERGY THEORY

The energy theory of buckling, propounded by Bryan (20) in 1889, was based on the law that a motionless conservative system is in a state of stable equilibrium if, and only if, the value of its potential energy is a relative minimum. According to the principle of virtual work, the first variation of the potential energy vanishes ($\delta V = 0$) for any equilibrium configuration. Equilibrium consequently ceases to be stable when the second variation $\delta^2 V$ ceases to be positive definite. The theory of the second variation is the sufficiency theory of the calculus of variations. This theory is very complicated, and its practical results are restricted mainly to single integrals involving ordinary derivatives. No doubt, this circumstance accounts for the fact that no problem of buckling of a deformable body has ever been solved rigorously by three-dimensional theory.

For a system with finite degrees of freedom, $\delta^2 V$ is a real quadratic form in the virtual increments of the coordinates, with the load appearing as a parameter in the coefficients. The theory of quadratic forms leads again to Poincaré's criterion for buckling, det $(\partial^2 V/\partial x_i\, \partial x_j) = 0$.

Although Bryan stated the energy principles of buckling correctly, he did not recognize the fundamental importance of the nonlinear terms in the strain tensor. This oversight led him to the erroneous conclusion that a convex closed shell cannot buckle. However, his application of the theory to buckling of compressed plates (21) is correct, since he shunted the nonlinearity into the potential energy of the external forces by means of the assumption that buckling causes no supplemental strain of the middle surface. In treating the plate problem, Bryan split the potential energy into a difference, $V = U - T$, in which U is the strain energy and T is the work performed on the system by conservative external forces. If equilibrium is stable, $\delta^2 V$ is positive definite, and therefore $\delta^2 U > \delta^2 T$ for all nonzero virtual displacements. Accordingly, the buckling load is the smallest load for which the equation $\delta^2 U = \delta^2 T$ can be satisfied with nonzero virtual displacements. Using a

double sine series to represent the deflection, Bryan applied this principle to the problem of buckling of a compressed rectangular plate with simply supported edges. Kirchhoff's expression for the strain energy was used. Bryan also used the eigenvalue theory to determine the buckling load of a compressed circular plate with a clamped edge. His work provided the first solutions of problems of buckling of plates.

Timoshenko (22) later expressed the buckling condition by the equation $\Delta T = \Delta U$. Since second-degree approximations were used, $2\Delta T$ and $2\Delta U$ were really represented by $\delta^2 T$ and $\delta^2 U$. Hence, Timoshenko's energy criterion for buckling is equivalent to Bryan's. The formula $\Delta T = \Delta U$ may be inferred from the first law of thermodynamics, $\Delta T = \Delta U + \Delta K$, where ΔK is the increment of kinetic energy that accompanies buckling. However, Ziegler (13) has made the surprising discovery that, when certain types of nonconservative external forces are present, the buckling load may be higher than the smallest load for which the equation $\Delta T = \Delta U$ can be satisfied with infinitesimal virtual displacements.

Timoshenko (22) used the buckling criterion $\Delta T = \Delta U$ in conjunction with a new application of the Rayleigh-Ritz method (23, 24). He thus obtained approximate solutions of many problems o. buckling of columns, beams, and plates. The buckled form was approximated by a prescribed function that contained a few undetermined parameters, and $\delta^2 T$ and $\delta^2 U$ were expressed in terms of those parameters. The parameters were then chosen to minimize the buckling load determined by the equation $\delta^2 T = \delta^2 U$. When it is used judiciously, this method is surprisingly accurate, and it has proved to be perhaps the most practical invention in all buckling theory. Since the buckling load is minimized in a class of deflection functions that is too narrow, the method necessarily leads to an approximation for the buckling load that is no less than the correct value. Unfortunately, no equally versatile method for establishing a lower bound for the buckling load has been devised. Trefftz (25) suggested that a lower bound is obtained if the class of admissible deflection functions is enlarged (e.g., by relaxation of boundary constraints or continuity requirements), and the problem is then solved exactly. For example, the buckling load of a plate with one or more hinged edges is a lower bound for the buckling load of the same plate with all edges clamped. Recently, Boresi (26) applied an analogous procedure to obtain a lower bound for the buckling pressure of a ring. He weakened the positive definite character of $\delta^2 V$ by reducing a positive term and increasing a negative term, and he solved the modified problem exactly. Another procedure for establishing a lower bound has been devised by Budiansky and Hu (27).

Trefftz (28) formalized and extended Bryan's energy theory of elastic stability. He restricted attention to the case in which the external forces are constants. Then, if no internal constraints are assumed (such as inextensionality of center lines or center planes), ΔT is a linear functional of the virtual increments of the displacement vector. Consequently, $\delta^2 T$ vanishes identically, and Bryan's stability criterion reduces to the condition that $\delta^2 U$ be positive definite. Therefore, when the buckling load is reached, $\delta^2 U$ becomes positive semidefinite; that is, the minimum value of $\delta^2 U$ is zero, and this value is attained for some nonzero virtual displacements u_i. Trefftz set $\delta^2 U = Q$, and he observed that the condition that Q possess a nontrivial minimum signifies that the variational equation $\delta Q = 0$ be satisfied identically for certain nonzero values of the functions u_i. The equation $\delta Q = 0$ yields linear homogeneous differential equations (the Euler equations of the calculus of variations) and homogeneous natural boundary conditions. Thus, the variational theory leads to the same linear eigenvalue problem as the equilibrium theory. Other extensions of the general theory of stability of conservative systems have been made by Southwell (29), Biezeno and Hencky (30), Prager (31), Pearson (32), and Bolotin (33).

DISSIPATIVE SYSTEMS

Engesser's tangent-modulus theory for columns, published in 1889, was the first analytical approach to problems of buckling of nonconservative systems. Engesser's revision of his theory to account for the Hookean behavior of the material on the convex side of a buckling column, and the subsequent corroboration of his analysis by von Kármán, are well known (1, 2). However, in 1947, Shanley (34) showed by a simple analytical model that bending theoretically can begin at the tangent-modulus load, despite the behavior of the material on relief of stress. To reconcile this conclusion with the analyses of Engesser and von Kármán, we must conclude that the equilibrium method does not necessarily yield the lowest bifurcation point of a system if dissipative forces are present. Shanley's investigation stimulated several careful studies of inelastic columns (35, 36, 37, 38, 39). Drucker and Onat (40) discussed the stability of inelastic systems from a more general standpoint. Recently, Hill (41) based a general theory of stability of rigid-plastic bodies on the following principle: "A sufficient condition for stability is that in any displacement from the position of equilibrium, within a definite (small) neighborhood, the internal energy stored or dissipated should exceed the work done on the body by the external loads." As Ziegler (13) has shown, this condition is not generally necessary for stability. Hill also relaxed compatibility conditions, so, by Trefftz's reasoning (25), his theory may yield a value for the buckling load that is too small.

SNAP-THROUGH THEORY

In practice, the mere existence of stability provides no assurance of safe design. What is important in engineering is the degree of stability. In 1939, von Kármán and Tsien (42) noted that some structures (particularly shell-like structures) may experience states of weak stability, such that small blows or other disturbances cause them to snap into badly deformed shapes. This condition, known as "snap-through," is characterized by a dip in the load-deflection curve. The theory of snap-through is essentially nonlinear, since it entails the study of buckled forms. Experimental observations of snap-through of carefully formed elastic cylindrical shells subjected to uniform external hydrostatic pressure have been reported by Kirstein and Wenk (43). Theoretical studies of the phenomenon have been undertaken by several investigators (44, 45, 46, 47), and they all conclude that snap-through is possible, although their results do not all agree quantitatively. Degree of stability may be measured by the amount of external work of lateral forces required to produce snap-through. For cylindrical shells, an investigation of this question has been undertaken (46). The fact that snap-through can often be produced with very little supplementary work suggests that the buckling load of the infinitesimal theory may be practically unattainable in some cases.

IMPERFECTION THEORY

Shanley's theory (34) showed that a certain indeterminacy is eliminated if a centrally loaded inelastic column is regarded as the limiting case of an eccentrically loaded column (35, 36, 37, 38, 39). This idea may be applied to any mechanical system; the behavior of the geometrically perfect system may be regarded as the limit that results if certain imperfections, eccentricities, or auxiliary lateral loads approach zero. This approach to buckling theory is known as the "imperfection method." Usually, the buckling of an imperfect structure is not of the bifurcation type. The stability problem is accordingly transformed to a nonlinear equilibrium problem for which a maximum load exists.

In recent years there have been numerous theoretical and experimental studies of shells with finite dents or out-of-roundness. Flügge (48) and Donnell (49) were pioneers in these investigations. Vol'mir (47) and Donnell (45) have recently conducted parallel analyses of the behavior of an imperfect cylindrical shell subjected to external pressure, and Nash (50) and Loo (51) have treated torsional loading.

Another ramification of the imperfection concept has developed in creep studies. A structure that is susceptible to buckling undergoes accelerated deformation if the material creeps, since the deformation aggravates the stresses, and the rate of creep consequently increases. The objective in an analysis of creep buckling is to ascertain the time interval in which the deformation will cause malfunctioning of the structure. Naturally, this time interval depends strongly on the magnitudes of initial imperfections; frequently it becomes infinite for a geometrically perfect structure. Most studies of creep buckling have dealt with columns. The more complicated problems of creep buckling of plates and shells are impeded by formidable mathematical difficulties, and by insufficient knowledge of the creep laws for biaxial states of stress. The existing theory of creep buckling has been developed in the last decade. Hoff's lecture (17) contains references to a number of papers on the subject.

DYNAMIC CONCEPTS IN BUCKLING THEORY

The fundamental frequency for infinitesimal vibrations of a statically loaded straight elastic column decreases as the axial load increases, and it becomes zero when the Euler buckling load is attained. This principle may be extended to other structures. Accordingly, problems of buckling of conservative systems may be regarded as special vibration problems. This point of view has been expounded by Massonnet (52) and Lurie (53).

Ziegler (13, 54) has recently demonstrated that dynamical principles are indispensable for analyses of certain types of buckling problems. He considers external forces that vary in a prescribed way with the deformations of the structure. Such forces are usually nonconservative, since their work depends on the path that they describe. Ziegler has shown that, when such forces operate, the statical theory may yield a buckling load that is too low, since the path of deformation prescribed by the statical theory may be inconsistent with the equations of dynamics. Ziegler suggests that a system be regarded as stable if infinitesimal initial velocities cannot carry it a finite distance away.

Another aspect of dynamics was introduced by Hoff (55), who considered effects of impulsive loads on structures susceptible to buckling. Such loads may exceed those that would cause collapse if applied steadily, since the inertial forces provide stabilization. Naturally, the response of a structure to impulsive loads depends essentially on slight eccentricities of the loads or imperfections of the structure. Zizicas (56) studied the dynamic response of an initially deflected plate subjected to transient loads in the plane of the plate. Such problems extend somewhat beyond the realm of buckling theory; they belong to the general theory of transient response of a nonlinear system.

THERMAL BUCKLING

Thermal stresses may cause buckling of a plate, shell, or fabricated structure. Critical states of stress for a geometrically perfect conservative system are independent of the cause of stress. Consequently, if the stresses are given, except for a constant factor K, the determination of the critical value of K requires no consideration of whether the stresses arise from heating, external loading, or residual strains, provided that the properties of the material are the same in all cases.

Thermal buckling is usually not disastrous unless the resulting deflections impair the operation of the structure. Consequently, the postbuckling deflections of a structure that is buckled by heat are of primary interest. This question presents a nonlinear equilibrium problem for which no real solution exists if the buckling point is not attained. Accordingly, in analyses of postbuckling behavior of an ideal structure, the classical buckling load is obtained as a by-product. Unfortunately, most of these nonlinear problems are so difficult that they can be handled only by rough approximations that reduce the systems to a few degrees of freedom. A few studies of postbuckling behavior of heated plates have been undertaken recently (57).

PRESENT TRENDS

The modern trend in buckling theory is marked by a deviation from the idealistic concepts of the classical theory. Large nonlinear deflections of structures, known as buckling, may result from various effects, such as statical loads, heating, creep, and impulsive loads. Although the infinitesimal theory of buckling should not be considered to be closed, practical investigations may no longer be limited to infinitesimal disturbances; the nonlinear problems associated with buckling have become practically important. Since geometric imperfections, inhomogeneities, eccentricities, residual stresses, and accidental shocks frequently have strong effects, statistical theories may be expected to play an increasingly important role in analyses of buckling.

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Theoretical and Experimental Methods

(See also Revs. 4342, 4343, 4360, 4368, 4369, 4377, 4378, 4379, 4382, 4384, 4395, 4438, 4587, 4588, 4596, 4607, 4687, 4716, 4718, 4819)

Book—4327. Alger, P. L., Mathematics for science and engineering, New York, McGraw-Hill Book Co., Inc., 1957, xi + 360 pp. $5.50.

This book is a revision of "Engineering mathematics" by C. P. Steinmetz published by the same company. It is intended for students in high schools, colleges and technical institutes, and also practical engineers.

It contains fourteen chapters: Arithmetics, Trigonometry, Directed numbers, Algebraic equations, Infinite series, Numerical calculations, Empirical curves, Differentials and integrals, Functions, trigonometric series, Maxima and minima, Differential equations, Probability and mathematical models and electric circuits. There are appendices of some tables on logarithms, trigonometrical functions, experimental and hyperbolic functions, and many useful formulas.

In the reviewer's opinion, this book, which is clearly written, will be welcomed by college students and practical engineers who need to apply mathematics in their work and who will use this book as a preliminary step for advanced study in higher mathematics. S. I. Pai, Germany

4328. Seth, B. R., Elastic and fluid flow problems for triangular and quadrilateral boundaries (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5**, 73–79.

Solutions are obtained to certain problems involving the Laplacian operator, when the field of operation is a triangle or trapezoid. Method uses trilinear coordinates and consequent transformation of the differential equation. L. Fox, England

4329. Angelitch, T. P., Equations of Beltrami-Michell type written in tensor notations (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5**, 302–305.

Book—4330. Kunz, K. S., Numerical analysis, New York, McGraw-Hill Book Co., Inc., 1957, xv + 381 pp. $8.00.

Text is intended to acquaint the reader with the best procedures available for obtaining numerical solutions to a wide variety of problems arising in applied mathematics. In most cases, several alternative methods are presented and the relative merits of each are described. The discussion proceeds largely through the use of heuristic arguments, symbolic methods, and numerous illustrative examples rather than through a rigorous mathematical development of the subject. The mathematical demands on the reader are thus very modest considering the relatively advanced topics included in the later chapters.

Chapter headings give a fair picture of the coverage: The real roots of an equation; Roots of polynomial equations; Finite-difference tables and the theory of interpolation; Central-difference interpolation formulas; Lagrange's interpolation formula and inverse interpolation; Summation of series; Numerical differentiation and numerical integration; Numerical solution of ordinary differential equations, methods of starting the solution; Solution of ordinary differential equations, methods for continuing the solution; Simultaneous equations and determinants; Interpolation in tables of two or more variables; Expression of a partial differential equation as a partial difference equation; Solution of partial differential equations of the elliptic type; Solution of partial differential equations of the parabolic and hyperbolic types; and Integral equations. A discussion of the estimation of error in numerical computation and a list of references are included in two appendices.

It is the reviewer's impression that the author has succeeded well in his task and has produced an account of a subject, which is almost as much an art as a science, that should be of considerable value to engineers and others who must employ numerical methods in the course of their work.

J. R. Spreiter, USA

4331. Frey, W., The application of theory and electronic computers to automatic control (in English), *Brown Boveri Review* **44**, 11, 468-472, Nov. 1957.

4332. Allakhverdiev, K. A., Approximate solution of a composite border problem for Laplace's equation by the method of lattices (in Russian), *Trudi Azerb. industr. in-ta*, no. 9, 47-61, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2099.

Paper is devoted to an examination of the following problem. Given two plane zones D_1 and D_2, where region D_1 is bounded by the contours σ and σ', and region D_2 by the outlines s and σ, having a limited curvature. Outline σ' is wholly contained within outline σ, while outline σ is wholly contained within outline s. A solution is sought for determining the harmonic function $u(x,y)$ in the regions D_1 and D_2 continuous on $D_1 + D_2 + \sigma + \sigma' + s$ and satisfying the border conditions

$$u(x,y) = f(s) \qquad \text{at } s \qquad [1]$$

$$k_1 \frac{\partial u}{\partial n_1} = k_2 \frac{\partial u}{\partial n_2} \qquad \text{at } \sigma \qquad [2]$$

$$u(x,y) = \varphi(\sigma') \qquad \text{at } \sigma' \qquad [3]$$

$$u_1 = u_2 \qquad \text{at } \sigma \qquad [4]$$

where k_1 and k_2 are given positive numbers, $f(s)$ and $\varphi(\sigma')$ are continuous functions, $\partial u/\partial n_1$, $\partial u/\partial n_2$ are respectively external and internal normal derivatives on outline σ. Such a statement of the problem is met within the theory of filtration in layers which are not homogeneous as regards permeability. The problem is solved by the method of end differences. In the solution use is made of the square lattice. For the nodal points, disposed on the lattice boundary σ dividing two adjacent regions, the differential equation is obtained by means of formula [2] by substitution of the normal derivatives by the corresponding differences. The solution of the problem converges with the system N of linear homogeneous and heterogeneous algebraical equations with N unknowns. Proof is given for two theorems: (1) the differences equation (representing the solution of the problem set) has only one solution for any arbitrary step of lattice h; (2) the differences equation can be solved by the method of successive approximations.

G. G. Vakhitov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—4333. Morse, P. M., Queues, inventories and maintenance, New York, John Wiley & Sons, Inc. (Publ. in Operations Research, no. 1), 1958, ix + 202 pp., $6.50.

This volume, the first in the series "Publications In Operations Research," sets a fine example and gives promise of a comprehensive literature on the basic concepts and practical applications of general use in the field. The series is jointly sponsored by the Operations Research Society of America and John Wiley and Sons. This volume grew from a study, supported by the Army Office of Ordnance Research, the object of which was to produce queuing tables of general interest. The author found that a short preface to the tables would be inadequate to define the subject and outline the fields of application. Professor Morse has produced an excellent introduction which, while intended to be expository, will allow the reader to make use of the techniques. The earlier chapters introduce probability concepts, the description of arrivals and service distributions and the single exponential channel. Here a somewhat new notation is introduced without adding to the confusion of "newcomers" or "old hands" to queue theory. The book includes discussions of multiple channels, priorities, transient solutions, maintenance problems and inventory queue models.

Throughout the work Professor Morse avoids straying from the practical path; sample problems are related to realistic problems in industry. Cost considerations, as well as service levels, are used to define optimal conditions. While the book is largely concerned with the analytical aspects of queue theory, simulation is not ignored; chapter 5 is titled "Simulation of nonexponential distributions."

There has been a need for a definitive volume on queue theory, if only to organize ideas and serve to standardize notation. This volume does even more; it develops the basic concepts in a clear and concise manner. It is not a book for the mathematically immature; some background in statistics and calculus is essential, as it should be for a comprehensive review of an important subject for Operations Research workers.

A glossary of symbols is provided which allows the volume to be used for reference purposes. The book also includes seven tables of great value to those using queue theory in real problems. The tables include, "Factorials of integers," "The Erlang density function," and "Poisson functions for Erlang channels."

E. Koenigsberg, USA

4334. Bellman, R., On a routing problem, *Quart. appl. Math.* **16**, 1, 87-91 (Notes), Apr. 1958.

4335. Peleg, M., Measurement units in traffic engineering, *Bull. Res. Counc. Israel* **6C**, 1, 33-42, Nov. 1957.

The introduction into traffic engineering of a system of units, similar to that used in mechanics and based on the CGS or on the metric system, is suggested. In addition to the unit of traffic capacity already in use, the units of number of vehicles, traffic momentum, traffic force, traffic power and traffic energy are defined and discussed. Examples are given for the use of some of these units for the comparison of the state of traffic on the road under different conditions, and for drawing practical conclusions referring to improvement of the traffic. Finally, a critical comparison of the terms "friction coefficient" and "braking coefficient" is given. From author's summary

Book—4336. Van Nostrand's scientific encyclopedia, 3rd ed., Princeton, New Jersey, Van Nostrand, 1958, 1839 pp. $30.

A new edition of the famous compendium published since 1938. Scope of contents is extremely wide: mathematics, physics, chemistry, geology, mineralogy, astronomy, meterology, botany, zoology, statistics; engineering: civil, mechanical, electrical, chemical, nuclear; **metallurgy**, aeronautics, navigation, radio and television, guided **missiles**, electronics, photography, and

medicine. 14,000 articles written and compiled by 36 contributing editors of high qualifications assure the high level of information gathered in this large volume, "so complete and accurate that it supplies the information needed by the professional, so simply written that it can be understood by any reader."

In comparison with previous editions new chapters are emphasized: electronics, television, nuclear science, guided missiles. More attention is shown to interplanetarian space than before. However, natural resources such as water, so vital for mankind, should not be neglected. Reviewer missed such articles as rivers, water discharge, gage, current meter, discharge measurement, discharge curve, runoff, gaging station, floods, silt, silting, water power development, lakes... A table of river discharges could be easily given, because analyses of river waters are listed (p. 1789). The Reynolds number, mentioned on p. 678 as well known, is inadequately explained on p. 1417.

Print is of high quality; it is regrettable that proofreaders have not obeyed modern standards, and left a mess of dimension units with periods and plurals, even in metric system! Some errors, like Canquillet instead of Ganguillet, should be corrected too. Encyclopedia is of great value as a single information book.

S. Kolupaila, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 4381, 4425, 4585, 4665, 4684, 4792, 4817)

Book—4337. Beer, F. P., and Johnston, E. R., Jr., Mechanics for engineers—Statics and dynamics, New York, McGraw-Hill Book Co., Inc., 1957, xvi + 673 pp. $8.

This is a very good text for engineering mechanics courses as taught in most universities in this country. The general arrangement is as follows, by chapter titles: Introduction; Statics of particles; Statics of rigid bodies in two dimensions; Statics of rigid bodies in three dimensions; Centroids and centers of gravity; Analysis of structures; Forces in beams and cables; Friction; Moments of inertia; Method of virtual work; Kinematics of particles; Kinetics of particles: Force, mass, and acceleration; Kinetics of particles: Work and momentum; Kinetics of particles: Impulse and momentum; Kinematics of rigid bodies; Kinetics of rigid bodies: Dynamic equilibrium; Kinetics of rigid bodies: Work and energy; Kinetics of rigid bodies: Impulse and momentum; Mechanical vibrations.

Book is well written and much effort has been made to explain the basic concepts in the text. Authors are very successful in showing the vectorial nature of mechanics concepts when appropriate. Dot and cross products are not introduced, however. An abundance of completely solved problems adds to the usefulness of the text. This book should win many friends among teachers and students.

A. Phillips, USA

Book—4338. Sommerfeld, A., The mechanics of deformable media (in Russian), Moscow, Izdvo in. lit., 1954, 487 pp.; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2627.

Book represents the second volume of the author's "Lectures on Theoretical Physics." As in the other volumes of these "Lectures," the present work does not contain a full and systematic exposition of the subject; only a few concrete problems of hydrodynamics and the theory of elasticity are examined.

The first three chapters of the book are devoted to the fundamental mechanics of continuous media: Chap. I to kinematics (also some information on vector and tensor analysis); Chap. II to statics; Chap. III to the fundamental equations of the dynamics of deformable bodies.

Chapters IV–VII discuss a number of problems of hydraulics: the vortex theory, theory of surface waves, theory of stream flows of incompressible fluids, Karman vortex trains. A very brief exposition is given of the theory of the boundary layer, theory of the slow flow of a viscous fluid and the hydrodynamic theory of lubrication, the theory of the unidimensional unsteady flow of a barotropic gas, and the theory of shock waves, theory of turbulence. Chapter VIII deals with some problems of the theory of elasticity. It includes, besides problems of flexure and torsion, the oscillations of elastic bodies (in application to the quantum theory of the heat capacity of solids) and the propagation of waves in an elastic semispace. An appendix examines the characteristics of motion and state in orthogonal, curvilinear coordinates, and the equations of motion of a viscous, incompressible fluid in cylindrical and spherical coordinates.

Book includes more than 30 various problems, with indications for their solution. The book is not encumbered with facts of secondary importance, but contains a number of interesting deviations into other branches of physical science not usually associated with the mechanics of continuous media. This circumstance, as well as the originality of treatment of many of the questions, and the clarity of exposition and proof make Sommerfeld's book a very valuable manual for a wide audience interested in mechanics.

G. G. Chernyi

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4339. Kline, L. V., Marco, S. M., and Starkey, W. L., Work capacities of energy storage systems on basis of unit weight and unit volume, *Trans. ASME* **80,** 4, 909–914, May 1958.

Paper compares energy storage per unit weight and volume of a limited selection of storage techniques. General equations and optimization analyses are developed for flywheels, springs, and compressed fluids. Treatment of chemical, electrical, and electrochemical techniques is limited to quoting pertinent data for gasoline, a solid propellant, a capacitor, and several electrochemical cells. The general observations on "best work-producing devices" are somewhat perilous, since weight and volume moduli of conversion of stored-energy to end-use form is so dependent upon system specifications and function.

R. W. Mann, USA

4340. Manea, V., Calculation of the virtual mass for an elongated slender body (in French), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 2, 1957.

A procedure is presented for the approximate calculation of the virtual mass of elongated slender bodies completely immersed in a fluid. For axial motion, the virtual mass is calculated for a particular type of slender body known in the source theory. For tridimensional motion and rotation, the plane motion in complex variable is used.

Applying this procedure to an ellipsoid of infinite elongation, author reaches the same result as obtained for tri-dimensional motion.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4341. Sokolov, A. P., Different aspects of equations of static equilibrium (in Russian), *Trudi Mosk. energ. in-ta* no. 17, 239–248, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 23.

Elementary proofs of known propositions for the conditions required to show that six equations of moments relating to six axes are sufficient for determining the equilibrium of the system.

E. N. Berezkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4342. Jankovic, Z., On the natural equation for brachistochrone (in English), 9th Congrès intern. Mêcan. appl., Univ. Bruxelles, 1957; **5,** 54–62.

Author considers the classical brachistochrone problem and adds some new details to it. By using the energy principle and com-

bining this with the centrifugal force, a vector equation equivalent to Euler's equation for the brachistochrone is obtained. This equation is called the "natural equation for the brachistochrone." From this, conditions that must be satisfied by brachistochrones going through the same point are derived. In addition, the question whether there is more than one field of force for which a given family is a family of brachistochrones is answered. These results are then applied to two particular cases: (1) homogeneous force field, (2) central field of force $k\bar{r}$. A table of various possible curves is given. Although the author confines his attention to the plane, he indicates how the space problem can be handled by analogous means.

E. J. Scott, USA

4343. Eraslan, N., Some properties of a family of curves and their applications (in French), 9th Congrès intern. Mêcan. appl., Univ. Bruxelles, 1957; **5,** 88–94.

Author treats family of curves defined by $x = a \cos \alpha + \lambda \cos^2 \alpha$ and $y = b \sin \alpha$ which give the locus of the point through which the resultant inertia force acts on a connecting rod in a simple crank and connecting rod mechanism. He shows that the area of these curves is always equal to that of the ellipse of $\lambda = 0$, while the c.g. is displaced from the center of the ellipse by 0.75λ.

Author proposes use of curve of this form for a high-speed cam and examines symbolically and graphically the conditions for such a curve to meet the requirements of tangency to the base circle and outer circle, but does not consider the utility of such a cam nor the form of the velocity or acceleration diagrams.

E. McEwen, England

4344. Roberson, R. E., Effect of air drag on elliptic satellite orbits, *Jet Propulsion* **28,** 2, 90–96, Feb. 1958.

Author reconsiders the equations of motion derived by Peterson [AMR **9** (1956), Rev. 3441] and provides approximate analytical solutions for small orbital eccentricity by the method of variation of parameters. Results are presented as simple expressions for change of eccentricity and angular advance with altitude. Effects of oblateness and rotation of the earth are discussed.

In a later paper [title source, **28,** 5, 330–331, May 1958] author shows how results may be applied to problem of inferring air density as a function of altitude from satellite observations,

H. N. Abramson, USA

4345. Roberson, R. E., Orbital behavior of earth satellites, Parts I and II, *J. Franklin Inst.* **264,** 3, 181–201, Sept. 1957; **264,** 4, 269–285, Oct. 1957.

Although the methods of classical astronomy are applicable to the analysis of orbits of close satellites, a need has existed for a treatment of intermediate accuracy of the effect of the oblateness of the earth, a major perturbation source under these conditions. Author reviews some of the more recent contributions toward this goal, compiles a number of orbital results of value in satellite engineering, and discusses some of the perturbation sources on a satellite orbit. He develops a solution of first order in the oblateness for orbits about an oblate spheroid by a method similar to Hansen's classical perturbation method. Particular attention is given to the effect of initial conditions on the orbit elements.

From author's summary

4346. Michielsen, H. F., The case for the low acceleration spaceship (in English), *Astronaut. Acta* **3,** 2, 130–152, 1957.

Paper deals with escape trajectories of space ships, wherein extremely low accelerations are applied. Many revolutions around the central attracting body are required for completion of such low-acceleration maneuvers. While low acceleration is shown to be less efficient than short-time high acceleration, the losses are not prohibitive and are balanced by certain advantages, that are discussed in detail.

From author's summary by H. N. Abramson, USA

4347. Davis, R. J., Wells, R. C., and Whipple, F. L., On determining the orientation of a cylindrical artificial earth-satellite, *Astronaut. Acta* **3,** 4, 231–236, 1957.

There are certain advantages to be gained by using the spent third stage of the satellite launching rocket as a separate satellite, to be observed for scientific data. If observations on such an object are to be useful, we must be able to determine its orientation observationally from the earth's surface to establish the coefficient of atmospheric drag.

A method is proposed for determining this orientation by observing the flash from a specularly reflecting cylindrical surface. Only half the surface would be made specularly reflecting; the other half would be a diffuse reflector to allow continuous observation of the object as well.

We have derived expressions from which one can determine the orientation of the cylinder from observations of the flash. We have assumed that the cylinder is tumbling extremely slowly, if at all. Although the problem of the more rapidly tumbling cylinder is also soluble, we do not discuss it in this paper, further than to suggest a test for tumble.

We have also experimentally determined the probability of obtaining sufficient observations of the flash to be useful. With our proposed positioning of observers, we would obtain the required three flash observations at approximately 20% of our observing locations. We believe that this probability is high enough to insure the success of a program based upon a cylindrical satellite such as that suggested, provided there is no physical deterioration or deformation of the satellite during launching.

From authors' summary

4348. Tipei, N., On the descent of rockets (in French), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 2, 1957.

Paper considers descent of a rocket in space, its thrust varying in magnitude and the variation of the gravitational field being taken into account. Complete solution is obtained by means of the power series of the velocity component ratio, or in a closed form for zero thrust.

Further, in compliance with the new data concerning the atmosphere at high altitudes, author shows that in the case of a descent in air, the density exponential law may be extended up to the extreme limit of the atmosphere. By transforming the motion equations in the hodograph plane, the solutions are first given under the assumption that the drag coefficient varies with the Mach number and then, considering this coefficient to be constant.

Staff, Revue de Mecanique Appliequee
Acad. Repub. Pop. Romane, Rumania

4349. Lazarev, L. P., Computation of the basic parameters of the movement of a missile attacking a rectilinear flying target (in Russian), *Sb. statei Mosk. vyssh. tekhn. ucb.-sbcba* **57,** 41–48, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 36.

By adding to the customary assumptions the supposition of the constancy of the speed of flight of the missile, author derives approximate analytical expressions for the parameters of the relative movement of the target in terms of elementary functions of time. The method of solution is built on the introduction of subintegral functions with the help of stepped series, followed by retention in them of the two first terms. Evidence of the convergence of the series is not adduced. Evaluation of the results obtained is carried out by numerical comparison with known solutions.

A. I. Zenkin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4350. Geballe, R., Statics and dynamics of a helical spring, *Amer. J. Phys.* **26,** 5, 287–290, May 1958.

The theory of the extension and twisting of a helical spring has been given quite completely in a recent paper by Krebs and Weid-

lich. This theory is reviewed and its applicability as an experiment in advanced mechanics is described. From measurements of extension and twisting under static load, and also from simple observation of the coupled oscillations of these degrees of freedom, it is possible to calculate Poisson's ratio and the shear modulus. The two independent procedures give consistent results. The experiment provides an excellent demonstration of the geometry and elastic deformation of a helix, its static equilibrium, and its coupled oscillations. From author's summary

4351. Gough, M. N., Sawyer, R. H., and Trant, J. P., Jr., Tire-runway braking friction coefficients, AGARD Rep. 51, 14 pp. + 9 figs., Feb. 1956.

A brief review is made of the problem of obtaining adequate tire-runway braking friction coefficients for use in determining the stopping distances of aircraft in landings. Methods and instrumentation used by the NACA for obtaining friction-coefficient data from full-scale airplane landings are described, and their limitations are discussed. Included also is a description of a friction-measuring cart to be towed over surfaces of interest. This device appears to offer an inexpensive method of obtaining data of the type desired by airport operators to provide information to pilots concerning surface conditions to be encountered in landings.
From authors' summary

4352. Fazekas, G. A. G., Some basic properties of shoe brakes, *J. appl. Mech.* **25**, 1, 7–10, Mar. 1958.

4353. Shtokman, I. G., Murzin, V. A., and Poluyanskii, S. A., Appearance of dynamic forces in the traction members of conveyors (in Russian), *Vest. mashinostroeniya* no. 7, 16–18, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1532.

Remarks on V. A. Kruzhkov's article show that Kruzhkov puts forward an incorrect assumption regarding the supposed fact that the dynamic tensions in the conveyor chain appear as the result of the hard impact of the teeth of the sprocket wheel on the articulations of the chain. In computing the velocity of spreading along the chain of the elastic wave the formula was adopted in error for the transverse oscillations instead of for the longitudinal oscillations. Some theoretical concepts and the experiments carried out led the authors to the conclusion that the dynamic forces in the chain at the usual velocities in conveyers ($v \leqslant 1$ m/sec) do not depend on the impact of the sprocket wheel on the chain articulations; these forces are determined by the irregularity of movement in the chain and can be significantly reduced by introducing compensating gear. V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4354. Levitskii, N. I., Drives in automatic machine tools and production lines (in Russian), "The automation of technological processes in mechanical engineering—Drive and control of machines," Moscow, Akad. Nauk SSSR, 1956, 23–48; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2704.

Paper discusses the selection of the law of motion of the follower element of a cam mechanism on the conditions of minimum pressure of the follower on the cam profile, simplicity of working of the cam profile, minimum energy consumption (loss) in the working of the mechanism, and reliability of the technical process in association with highest productivity.

The fundamental laws of motion are classified and characterized. It is demonstrated that in the selection of the laws of speed v and acceleration a, it is essential to avoid a succession of soft and hard impact blows. To decrease the maximum values of v and a it is necessary to displace the center of gravity of the curve of a to the commencement of the time interval. Minimum values of a are, however, only useful in the absence of abrupt variations of a; owing to the oscillations produced by the elasticity of the elements of the mechanism, abrupt variations of v and a lead to increased dynamic loads, which may considerably exceed the nominal values (corresponding to the curve of a).

A calculation is made for the force of the closing spring, of the maximum torsional moment on the cam, and maximum pressure of the follower on the cam profile.

It is pointed out that the most advantageous profiles from the aspect of manufacturing accuracy, and simultaneously the most accurate, are cam profiles produced by a hobbing action.

Examples are given. V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—4355. Blaschke, W., and Muller, H. R., Plane kinematics [Ebene kinematik], Munchen, Germany, R. Oldenbourg, 1956, 269 pp. DM 26.80 (paperbound).

In this book, the fifth volume of "Mathematical Monographs," are the lectures on plane kinematics delivered by the authors in their respective Universities. The book contains four parts; although they seem directed more to the geometer than to the university engineer, the latter will find, mainly in the two first parts, very valuable information on questions related to applied kinematics. Relative axes are systematically used throughout the work.

In the first part (Zwangslaufige Bewegungsvorgänge im Kleinen) authors assume two Euclidian planes, a movable one E gliding on an immovable one E', each plane containing a system of rectangular axes. The vector joining the two origins is projected (u_1,u_2) on the movable axes, and the two unity vectors along the movable axes are expressed as function of the unity vectors along the immovable axes and as a function of the angle θ between the two systems of axes. When u_1,u_2 and θ are given as function of time t, a constrained motion process B relative to planes E and E' is defined.

The vector joining a point movable in the movable plane to the origin of the immovable axes is then expressed as a function of the vector joining the two origins and the vector joining the considered point to the origin of the movable axes.

By deriving this equation as a function of time, the relation between the velocities, the properties of the instantaneous center (velocity pole), the properties of the centrodes, and their application to some special motions are deduced.

The relation between the accelerations are obtained by a second derivation. The advantages of using a third system—and eventually more systems—of relative axes are shown for finding the properties of velocity poles, namely in relation to kinematic chains. Numerous problems related to the construction of the center of curvature and to the properties of paths and envelopes are treated by this method. The particular case of the trochoides and their application to straight gears are considered and complex numbers are used for resolving problems concerning accelerations of higher order.

At the end of this first part will be found a general study on kinematic chains treating the question of the degrees of freedom and of the Grübler's condition of constrained motion. Different four-bar mechanisms are considered; complex numbers are used for determining the curve described by a point of the connecting rod; finally, the special mechanisms used for realizing exactly and approximately straight line motions are studied.

In the second part (Zwangslaufige Bewegungsvorgänge im Grossen) the functions u_1, u_2 and θ are supposed to be periodic functions of time, and the area contained in a closed curve described by a point attached to the movable plane is calculated with the formula of Gauss. This point is then supposed joined to a point of the immovable plane; the swept area is calculated and

applied to special cases, namely to the Amsler polar planimeter and to the determination of length and of total curvature of paths.

A straight line is then supposed attached to the system of movable axes and some problems concerning the envelope of the straight lines (for instance, length, area contained, swept area) are treated.

In the third and fourth parts higher mathematical tools are used. The third part, "Flächenläufige Bewegungsvorgänge," deals with the development of surface motion by using Pfaff forms or linear differential forms. With the aid of this powerful procedure the properties of motion are obtained in a very general manner. Of course all known properties are found again in a very elegant way and other properties are deduced; all of them appear in the new light and power of the involved mathematical instrument.

After having defined the density of polar axes, the motion is treated for the case of vanishing density and for the case of a prescribed distribution of polar axes. To a prescribed distribution of polar axes there corresponds a simple variety of surface motion processes, and, after the introduction of a contact transformation, these processes are uniquely connected with the contact representations in the plane which are interchangeable with all dilatations. These considerations are illustrated with their geometrical significance representation. Further interesting topics deal with dual or reciprocal motion.

The development of the fourth part, "Die Kinematische Abbildung," is based upon the use of quaternions to represent plane motion and inverse plane motion. A brief survey is given of the conditions which the quaternion units must fulfil. The theory is based upon geometrical considerations such as quasi-elliptical geometry in which notions of quasi-distance, quasi-angle and quasi-displacement are developed and as a consequence of which follows a quasi-elliptical theory of curves and a quasi-elliptical theory of surfaces, of quasi-elliptical parallel surfaces and quasi-elliptical displaced surfaces. Surface motion processes in the kinematical representation are considered in quasi-elliptical space.

Complete information on the origin of the different topics treated is given throughout the book, and a great number of exercises are proposed to the reader at the end of each part.

"Ebene Kinematik" is a book of very high standing. Its conception is of an outstanding character because of the penetrating manner in which the problems are treated and the use in a most elegant scheme of analytical methods of development. The book will therefore prove invaluable to those students who wish to have a deeper insight into the problems of plane kinematics.

D. De Meulemeester and H. L. Vanderlinden, Belgium

4356. Lohse, P., Geometrical loci of poles as aids in the solution of linkage (in German), *ZAMM* **38**, 1/2, 20–28, Jan./Feb. 1958.

With the help of "positional families" of a mechanism, the geometric loci of the poles are introduced as "polar loci curves" and a generalized basic problem of synthesizing proportions is formulated. Some examples are given to show the possibilities of application.

From author's summary by C. E. Balleisen, USA

4357. Bugaievski, E., Bogdan, R., and Pelecudi, C., Contribution to the classification of spatial mechanisms (in German), *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2**, 1, 1957.

For solving various problems of structural analysis and synthesis, paper aims at establishing some relations between the kinematic chains on the basis of complexity criteria.

For this purpose, a series of structural relations were determined, allowing a comparison of the chains. These relations were used to elaborate a classification based upon the number of links and closed contours. The classification is given as a table which allows certain common characteristics of the chains to be emphasized, and, by pointing out the influence exercized by the modified complexity upon the structural complexity, a general survey of the problem is given.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4358. Bogdan, R., Pelecudi, C., Bubalevski, E., and Calmaciuc, L., On the experimental determination of paths in plane mechanisms (in German), *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2**, 2, 1957.

Authors describe a mechanical-electrical transducer by means of which the displacements in plane mechanisms are indicated on an oscilloscope screen. The mechanical transducer uses two connecting rods which transform the plane motion into two rectilinear orthogonal motions. The error introduced in the transducer due to the finite lengths of connecting rods is sensibly reduced through the use of compensators in the electric device.

The described equipment may be successfully used in the experimental analysis and synthesis of plane mechanisms.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4359. Artobolevskii, I. I., One feature of the mechanism of the inversor (in Russian), *Doklady Akad. Nauk SSSR* **104**, 6, 825–827, 1955; Ref. Zh. Mekh. no. 1, 1957, Rev. 151

The mechanism of the inversor is laid out schematically, where two points move along reciprocally-inversional curves; at the same time, depending on the nature of the movement of one of the points, the other describes a curve which is straight, elliptical, parabolic or *sis*-soidal.

A. A. Dolgolenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4360. Sieker, K. H., Algebraic measure synthesis of a linkage (in German), *Ing.-Arch.* **24**, 4, 233–257, 1956.

4361. Mack, C., Theory of the spinning balloon, *Quart. J. Mech. appl. Math.* **11**, 2, 196–207, May 1958.

Many dynamical systems can be represented to good approximation by differential equation of motion, especially in textile processing; e.g. in ring spinning, cap spinning, unwinding, etc. These equations are obtained for a flexible uniform string rotating with a constant large angular velocity about a fixed axis when the string has a constant velocity along its length and air drag per unit length is proportional to a fixed power of the normal component of air velocity and acts in the direction of this component. For steady-state curves the equations are solved, a formal solution being obtained for the case of zero air-drag, and an expansion for finite air-drag. Reference is made to publications by J. Detry, S. Goldstein, A. Porter and L. N. Ginzburg.

J. J. Polivka, USA

4362. Johnson, R. C., Impact forces in mechanisms, *Mach. Design* **30**, 12, 138–146, June 12, 1958.

4363. Pisarev, M. N., Problem of mechanical linkages of different families (in Russian), *Sb. statei Vses. zaoch. politekhn. in-ta* no. 14, 90–97, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1525.

The question is discussed of the minimum number of links composing the mechanism of different families according to I. I. Artobolevskii's classification. The scheme worked out by the author for the investigation of the structures of mechanisms does not vary significantly from the earlier accepted method evolved by Artobolevskii.

V. A. Zinov'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4364. Ortman, F. W., and Green, H. M., Isoelasticity in gyro rotor bearings, ASME Fall meet., Hartford, Conn., Sept. 1957. Pap. 57-F-34, 16 pp.

Drift of a precision gyroscope, under external loads, from an initial orientation is caused in part by a shift in the center of gravity of the rotor with respect to the gimbal axis. The shift or yield is the resultant effect of the external loads acting upon all elastic components which make up the gyro. Since rotor and gimbal bearings are included in the more elastic components group, it is desirable that their behavior be predicted with a high degree of accuracy. Paper presents design information which may lead to an isoelastic bearing pair or to a bearing pair having specified axial to radial yield-rate ratios. Owing to nonlinear yield rates of bearings, the degree of departure from a true isoelastic bearing pair is calculated for a specific bearing configuration under the influence of a constant load at loading angles ranging from the axial to radial directions. From authors' summary

4365. Ishlinskii, A. Iu., On the theory of the gyroscopic pendulum (in Russian), *Prikl. Mat. Mekh.* **21**, 1, 3-16, 1957. (Translated from Russian by M. D. Friedman, Inc., 67 Reservoir St., Needham Heights, Mass., 1-114, 16 pp.)

Author discusses the motion of a two-rotor gyroscopic compass if the suspension point moves with given velocity and acceleration over the surface of the earth. The discussion is simplified by the introduction of an auxiliary nonrotating sphere. Author gives the equations in full length and, after making use of some approximations, succeeds in eliminating many unknowns, arriving at two differential equations of the first order for the two important angles of the system. For small values of these variables, the equations are linear with variable coefficients. General solution by means of quadratures. The Schuler condition.

O. Bottema, Holland

4366. Ishlinskii, A. Yu., Theory of the horizontal gyrocompass (in Russian), *Prikl. Mat. Mekh.* **20**, 4, 487-499, July-Aug. 1956.

Author deduces the theory of the horizontal gyrocompass whose main element is analogous to the gyrosphere of the known German gyrocompass "New Anschütz." The essential part of this compass is two gyroscopes with the gyroframe whose center moves on a immovable sphere. The gyroframe represents a mechanical system with four degrees of freedom. Following elementary gyroscopic theory, the relations between the angular moment, the gyroframe's angular velocity, and the moments of the forces are deduced, and relative motion of the frame with respect to the earth is treated. Using movable Darboux's trihedron, with the origin in the point of the suspension of the gyroframe, coupled with the trajectory of this point, the equations of small relative motion of the frame with respect to this trihedron are established. These equations represent the equations of forced vibrations. Supposing small vibrations, neglecting the friction forces, one obtains the system of four simultaneous linear differential equations with constant coefficients. This conclusion is opposite to the approximative theory of Geckeler. The friction forces produce the ballistic deviations, i.e., new changes of the variables.

D. Raskovic, Yugoslavia

Servomechanisms, Governors, Gyroscopics

(See also Revs. 4331, 4364, 4366, 4382, 4547, 4687, 4751)

4367. Babister, A. W., Optimum conditions of response of linear systems with constant coefficients having one degree of freedom (in English), 9th Congrès intern. Mécan. appl. Univ. Bruxelles, 1957; **5**, 29-38.

Paper indicates a new criterion for optimizing the transient response of a stable system. Certain drawbacks of the existing criteria (namely: "mean-square optimum"-MSO and "time-times-absolute value of error"-ITAE) are discussed first. Author shows that, by supplementing the MSO criterion by the "mean-square velocity," MSV criterion, one can obtain a response of a less oscillatory value if the MSO criterion is taken for its minimum value and the MSV criterion is used for a value less than that corresponding to the minimum.

Author illustrates the application of this method for (1) free motion; (2) step function disturbance. In the latter case two subcases are considered: (2a) zero-displacement error system; (2b) higher-order systems. Results of these calculations are plotted and the corresponding curves are compared to similar curves yielded by other methods.

It is pointed out that the advantage of this method is that it can be extended to systems of any order. The paper is clear and precise but somewhat confused notations, unfortunately, complicate its reading.

N. Minorsky, France

4368. Bigret, R., Mathematical and functional definition of hydraulic circuits (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 296-306.

Author concludes that the mathematical and computational techniques which have been signally successful in the analysis and synthesis of electrical and electronic control devices have been rarely applied to hydraulic systems. By examples he shows how transfer functions, servo-type schematic diagrams, and parameters can be defined if the parts of the systems operate in an almost linear fashion. He recommends the use of analog computers for analyzing and optimizing any proposed design.

H. M. Trent, USA

4369. Ostrovskii, G. M., The formation of zones of stability (in Russian), *Avtomatika i Telemekhanika* **16**, 6, 501-507, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 80.

The formation of zones of stability is carried out, determined by Hurvitz' criterion, in the plane of two coefficients of a differential equation of the order n with constant coefficients.

B. S. Razumikhin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4370. Voronov, A. A., Methods of calculating frequency characteristics by transition processes (in Russian), Trudĭ Vses. soveshch. po teorii avtomat. regulirovamiya, **2**. Moscow-Leningrad, Izd-vo Akad. Nauk SSSR, 1955, 41-52; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 118.

A short survey is given of the development of frequency methods, various ways of calculating frequency characteristics by means of the curves of transition processes, the construction of a material frequency characteristic, determination of the parameters of the system by means of the frequency characteristics and transition processes, described in the works of Russian and foreign authors.

A. M. Egorov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4371. Nishihara, T., Sawamura, T., and Naito, G., The optimum underlap in the pilot valve of the hydraulic servomechanism, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 443-448.

Taking the breaking point of the frequency characteristic as the basis to judge the performance of the hydraulic servomechanism, the effect of the underlap in the pilot valve on the breaking point frequency under various load conditions is investigated analytically and experimentally. Then a method to decide the optimum underlap which maximizes the break point frequency is given.

From authors' summary

4372. Ikebe, Y., Researches on fluid-servomoters: 3. On some fundamental properties of valve-controlled integral-type hydraulic servomotors, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 449–454.

4373. Ikebe, Y., Ito, K., and Harada, S., Researches on fluid servomotors: 4. On some fundamental properties of valve-controlled integral-type hydraulic servomotors, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 455–459.

4374. Magnus, K., Oscillations occurring in an unsteady temperature control loop with time delay (in German), *Forsch. Geb. Ing.-Wes.* **23,** 5, 169–175, 1957.

In order to attain simple equipment, relay controlling devices are frequently applied to temperature control loops, though a certain oscillation of the control variable cannot be avoided for this case even in the steady state. The influence of an almost always existing time delay on the amplitude, and on the period of the steady oscillation, is investigated for two different relay characteristics (with hysteresis or with dead range, respectively). A stability diagram serves to determine the general properties of the system. From author's summary

4375. Pyrometer indicator giving highly sensitive automatic temperature control, *Instrument Practice, United Kingdom,* Sept. 1956, p. 811 (*E.T.D.*, 1957, p. 505).

Courtesy European Technical Digests

4376. Lawrence, J. O. N., and Powell, R. D., The application of servomechanism analysis to fuel control problems, Instn. Mech. Engrs. Lond., Prepr., 22 pp.

Paper gives details of the way in which servomechanism techniques have been applied to accessory control problems. The emphasis has been on the correlation of theory with practice and typical results are given from tests on some 15 British gas-turbine engines. For completeness, a brief introduction to the basic concepts is first dealt with, then examples are given of linear and nonlinear theories applied to typical working systems.

It is pointed out that though the examples refer to hydraulic, mechanical, and thermodynamic processes the ideas may be carried forward into widely differing fields.

From authors' summary

Vibrations, Balancing

(See also Revs. 4337, 4353, 4525, 4694)

4377. Rosenberg, R. M., On the periodic solutions of the forced oscillator equation, *Quart. appl. Math.* **15,** 4,341–354, Jan. 1958.

The purpose of this paper is to study both odd and even subharmonics of an oscillator whose "elastic force" may be stable or unstable and linear or nonlinear. It represents a generalization of the earlier studies of odd-ordered subharmonics. It is found that the equation for a simple (i.e. single) subharmonic must have a particular set of coefficients which define the relation between the parameters of the equation and the amplitude and frequency of the steady-state response.

The stability of these solutions, i.e. the tendency of a solution and a perturbation to return to the basic solution, is studied approximately. It is found that the simple subharmonics do not have large areas of stability. However if the equation has a strong subharmonic solution, where a strong subharmonic is defined as a simple subharmonic plus higher-order subharmonic terms, then it is more likely to be stable.

The solutions are found by substituting an assumed form into the equation and finding the relation between the coefficients.

By using the results given in this paper it is possible to calculate the steady-state amplitude of a single-degree-of-freedom system to a sinusoidal excitation if the spring constant can be written in polynomial form. It is easy to imagine practical problems that could use the technique given in this paper.

E. E. Covert, USA

4378. Laitone, E. V., On the damped oscillations equation with variable coefficients, *Quart. appl. Math.* **16,** 1, 90–93, Apr. 1958.

Paper discusses oscillatory solutions of second-order differential equations in which coefficients of stiffness and of damping are time-dependent. Bounds can be given to solutions when a certain function of the coefficients is increasing, or decreasing, monotonically.

Theory can be applied to directional stability of a missile which is changing speed and moving in a region of air density change. D. C. Johnson, England

4379. Takei, K., Consideration of vibrating systems by phase-plane displacements. Part I. *Sci. Rep. Res. Inst. Tohoku Univ. Japan (B)* **8,** 1, 49–60, June 1956.

Paper develops a "phase-plane-double-delta" method for graphical solutions of second-order ordinary differential equations which avoids the restriction of a constant coefficient inertia term required by the Jacobsen phase of plane-delta method. The method is illustrated on linear systems with (a) decreasing mass, (b) negative inertia, (c) multiple restoring forces and masses, and on a system with a nonlinear inertia term.

M. G. Scherberg, USA

4380. Oniashvili, O. D., Approximate solution of some problems in the nonlinear theory of envelopes (in Russian), *Trudi in-ta stroit. dela Akad. Nauk Gruz. SSR* **5,** 11–20, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2176.

An examination is made, following the nonlinear theory, of the deflections, oscillations and strength of elastic, sloping envelopes, rectangular in plane and freely open along the edges. It is assumed that the principal curvatures of the central surface of the envelope up to the point of deformation are constant values. The problem leads to the known nonlinear equations relating to the stress function φ and the deflection function ω. The solution is sought by means of the integration of these equations, using Bubnon's method, when

$$\varphi = \sum_{mn} A_{mn}\varphi_{mn}, \qquad \omega = \sum_{mn} B_{mn}\omega_{mn}, \qquad Z = \sum_{mn} C_{mn}Z_{mn} \qquad [\bullet]$$

$$\varphi_{mn} = \omega_{mn} = Z_{mn} = \sin\frac{mx}{a}\sin\frac{my}{b}\ (m, n = 1, 2, \ldots)$$

Hence Z is the normal surface load, a the length, b the breadth of the panel. Inserting [•] in the equilibrium equation, author obtained the incorrect equations [3], which give for selected values m and n two relations, containing only the corresponding (values) A_{mn} and B_{mn}. Actually, equations [3] are only correct in the case when, in the series [•], one term is taken up at a time. Continuing, author confines himself to this first approximation. He faces the problem of determining the influence of the nonlinear factors (the so-called secondary effects) on the amplitude of the deflection, frequency of natural oscillations and the critical load, while establishing such boundary slopes as will ensure an error not exceeding 5% in the application of the linear theory. It has to be noted that the solution of the nonlinear problem in the first approximation may itself result in error exceeding 5%. Calculations are put forward for some ferro-concrete coverings of cylindrical and spherical shape, and also for a

double curve. It is shown that the linear theory gives lower values for deflection and stresses and higher values for the critical external pressure and frequency of natural oscillation.

Kh. M. Mushtari

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4381. Lebedev, A. A., The stability of an irregular movement over a finite range of time (in Russian), *Trudi MAI* no. 50, 7–25, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1488.

An account, with some insignificant supplements, of previously published results of G. V. Kamenkov and the author.

The stability of the trivial solution of the system

$$\frac{dx_i}{dt} = \sum_{j=1}^{n} p_{ij}(t)x_j + X_i \qquad (i = 1, \ldots, n)$$

over the interval of time $[t_0, t_0 + \tau]$ is determined by the condition

$$\sum_{i=1}^{n} \left(\sum_{j=1}^{n} a_{ij}x_j \right)^2 \leqslant A, \text{ when } t_0 \leqslant t \leqslant t_0 + \tau$$

where A is a sufficiently small positive number.

Applying Lyapunov's method, author introduces another determination of the stability. The undisturbed movement is stable over the interval $[t_0, t_0 + \tau]$ if the disturbance satisfies two conditions

$$V(t; x_1, \ldots, x_n) \leqslant A, \quad D(t) \leqslant D(t_0) \text{ when } t_0 \leqslant t \leqslant t_0 + \tau$$

where $D(t) = \sup 2\left(\sum_{i=1}^{n} x_i^2 \right)^{1/2}$ on the surface $V(t, x_1, \ldots, x_n) = A$.

Assuming that Lyapunov's function can be examined as a structure in the form of

$$V = \varphi^2(t) \sum_{i=1}^{n} \alpha_i^2(t) \left(\sum_{i=1}^{n} \alpha_{ij}(t)x_j \right)^2$$

where $\varphi(t) \geqslant S > 0, \quad |\alpha_i(t)| \geqslant \delta > 0 \qquad (i = 1, \ldots, n)$

are uninterrupted together with their first derived functions, author obtains the conditions for the selection of function $\varphi(t)$, directly following from the conditions $D(t) \leqslant D(t_0)$ and $dV/dt \leqslant 0$ (conditions of theorem 2).

Comment by the abstractor:

The peculiarities of the problem of stability over a finite period of time are indicated in the presentation of the problem (A, λ, t_0, T) of stability by N. G. Chetaev, where A and λ are positive numbers, determinable by the conditions of the concrete problem. Stability over the period $[t_0, T]$ can take place if for any and all initial disturbances $x_1^0, \ldots, x_n^0$, satisfying the condition $(x_1^{02} + \ldots + x_n^{02})^{1/2} \leqslant \delta$, the corresponding solution $x_1(t), \ldots, x_n(t)$ satisfies the condition

$$(x_1^2 + \ldots + x_n^2)^{1/2} \leqslant A \text{ when } t_0 \leqslant t \leqslant T$$

Here N. G. Chetaev showed that the problem (A, λ, t_0, T) of stability may be covered by Lyapunov's problem under the following (the conditions of Lyapunov's theorem excepted) additional limitations imposed on the function $V(t; x_1, \ldots, x_n)$:

If the function $c(t)$ is such that $\lambda = \inf(x_1^2 + \ldots + x_n^2)^{1/2}$ on the surface $V = c(t)$ when $t_0 \leqslant t \leqslant T$, then function $D(t) = \sup(x_1^2 + \ldots + x_n^2)^{1/2}$ on the surface $V = c(t)$ satisfies the condition $D(t) \leqslant A$ when $t_0 \leqslant t \leqslant T$.

The indicated peculiarities, important in applications to technical problems and essential constituents of the stability problem over a finite period of time, are not taken into account in the author's presentation, as in the work being reviewed the indispensable limitations for the value of A and a_{ij} are absent.

B. S. Razumikhin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4382. Malkin, I. G., Near-periodic oscillations of nonlinear nonautonomous systems (in Russian), *Prikl. Mat. Mekh.* **18,** 6, 681–704, 1954.

4383. Abashize, A. I., A method of determining the frequency of specific vibrations (in Russian), *Izv. Tbilissk. n.-i in-ta sooruzh. i gidroenerg.* **9,** 137–149, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 985.

The equation of the line of deflection of a single-span beam of constant flexibility is expressed as $y = f(x)$, where $f(x)$ is a function, the form of which depends on the way the supports are fastened. This function also contains the parameters characterizing the static load. Author makes an approximation for this function in the form of a trigonometrical or stepped series, converging in form to the specific vibrations of the beam; for the determination of any arbitrary frequency he leaves in it terms corresponding to the given form of vibration. Assuming the harmonic nature of the vibrations, the static loads are replaced in the original equation by the inertia forces of the vibration movement, after which the frequency of the specific vibrations is determined. Examples are given, confirming the adequate accuracy of the method with far less labor by comparison with the accurate solutions.

V. P. Shidlovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4384. Vodicka, V., A class of problems on longitudinal vibrations, *Quart. appl. Math.* **16,** 1, 11–19, Apr. 1958.

Author considers the subject problem for heterogeneous bar of length l and constant cross-sectional area q formed of n parts with lengths l_k, densities ρ_k and Young's moduli E_k ($k = 1,2,3 \ldots n$). The usual interface conditions of continuity of displacements and strains are assumed. The novelty consists in using matrix algebra in keeping book on the Laplace transforms which are used to solve the fundamental linear differential equation of such vibrations.

Most of the work is limited to the case for which $E_k\rho_k$ = constant ($k = 1,2, \ldots n$). In this case it is much easier to calculate the fundamental matrix.

Several well-known examples are studied. These are the vibration of bar under its own weight, bar with mass at end, and, finally, collision of two bars.

Reviewer considers that condition of $E\rho$ equal a constant is rather artificial and questions the author's statement that he is thereby treating an interesting class of problems.

W. H. Hoppmann, II, USA

4385. Hamburger, L., On connecting-rod vibrations in reciprocating engines (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2,** 2, 1957.

Paper concerns the natural frequencies of variable-section connecting rods of reciprocating engines, with respect to the fundamental resonance.

Considering various types of such rods, author finds that a linear dependence on the length may be admitted for both area and

momentum of inertia of cross sections, within allowable limits of error.

Solution of the Bessel-type equation of the natural longitudinal vibrations shows that there is no essential difference of behavior between the constant and the linear-varying section connecting rods.

For the transverse vibrations, a complete equation is obtained, integrated by means of the Galerkin approximation, considering rotation and shear also. Effects of rod end reinforcements are estimated.

Final conclusions are that under the actual conditions no risk of fundamental resonance may occur, even in high-speed machines, both for the longitudinal and transverse vibrations of connecting rods.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4386. Kornhauser, E. T., and Van Hulsteyn, D. B., Variational treatment of arbitrary mass-loaded membranes, *J. acoust. Soc. Amer.* **29,** 11, 1204–1205, Nov. 1957.

Paper treats title problem for membrane of arbitrary planform. Author shows trend of natural frequencies as radius of disk of constant mass shrinks to zero. Mass is constrained to translation normal to surface. Unlike results of Cohen and Handelman, AMR **10**(1957), Rev. 3917, dealing with disk of constant density, frequencies always decrease as radius shrinks.

R. Plunkett, USA

4387. Stein, B. A., Light-ray modulation method for detection of blade vibration, *WADC TN* 56-416, 28 pp., May 1957.

The need for a sensitive, accurate, vibration displacement and wave-form pickup is pointed out. Various methods are considered leading to the choice of a modulated light-ray phototube technique as being adequate. Choice of components and design are indicated. The final unit utilizes the focused image from a linear filament miniature light bulb and an IP42 vacuum phototube pickup to feed an amplifier circuit through a cathode follower mounted with the pickup. Final display is on the screen of a cathode ray oscilloscope equipped with a dual trace preamplifier. Calibration techniques are discussed and suitable mechanisms proposed for this purpose. A final evaluation of the unit is given in conclusion.

From author's summary

4388. Carter, A. D. S., and Kilpatrick, D. A., Self-excited vibration of axial-flow compressor blades, *Instn. mech. Engrs. Proc.* **171,** 7, 245–282, 1957.

Blade vibration problems and associated explanations are discussed and a resulting experimental program on blade flutter is described. On cascades, stalling, shock stalling, and choking flutter are identified. In compressors, these phenomena are associated with stall cells, either random or rotating at some percentage of compressor speed. Equating energy input to blade (during flutter) to energy absorbed by mechanical damping, and evaluating the constant from limited test data, results in a simple design rule:

$$\text{Critical velocity} = 0.020\, t\, f / r$$

where t is maximum blade thickness, f is fundamental bending frequency, and r is the ratio of blade to air density.

Significant additional data, historical and experimental, are presented by discussors. Several protested the design rule as without theoretical justification and not agreeing with test results.

E. T. Welmers, USA

4389. Plunkett, R., Interaction between a vibratory machine and its foundation, *Noise Control* **4,** 1, 18–22, Jan. 1958.

Vibration analysis of a machine on a foundation, in which the mechanical response of the latter is not included, is subject to error in the estimation of resonant frequencies, on the one hand, and vibration level on the other.

Analysis for simple one-degree-of-freedom system indicates that vibration isolator is relatively inefficient unless its mobility is high compared with those of both machine and foundation.

A particular experiment on actual effectiveness of low frequency mount indicates validity of first statement.

M. St. Denis, USA

4390. Mahalingam, S., Torsional vibrations of a multi-rotor system having a non-linear flexible coupling, *J. roy. aero. Soc.* **61,** 563, 779–781, Nov. 1957.

The free and forced vibrations of a multirotor system where one section of the shaft has a nonlinear elastic characteristic are considered. For any frequency of steady vibration the system is reduced to an equivalent rotor at either end of the nonlinear section. The vibrations at all points are assumed to be one-term approximate solutions and the amplitudes of steady forced vibration are determined by a method outlined by the author in an earlier paper.

From author's summary

4391. Mazet, R., An acceptable model for the study of thermo-elastic vibrations of a bar during creep (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 293–298.

Model consists of spring-mass elements in series with Coulomb friction between each element. The system is thermally isolated with the exception of the support, which is held at a constant temperature. Justification for and discussion of model is included.

A. H. Hausrath, USA

4392. Fraejis De Veubeke, B. M., A variational approach to pure mode excitation based on characteristic phase lag theory, *AGARD Rep.* 39, 23 pp., Apr. 1956.

In this interesting paper, author discusses forced motion in linear damped systems. Characteristic phase lag theory is used to define frequency response modes and corresponding excitation modes which possess simple energy or orthogonality properties. Response can be expressed in relatively simple form in terms of the characteristic phase lags, modes, and excitation. Active and reactive energies are defined, and it is shown that total reactive energy input per cycle is stationary with respect to small variations in the distribution and intensity of the exciting forces provided there is, simultaneously, resonance and pure mode excitation. Reference is made to ground resonance testing.

J. L. Bogdanoff, USA

4393. Rautu, S., Calculation of vibrations by successive approximations (in Russian), *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2,** 2, 1957.

First part of the paper deals with the dynamic analysis of frames by means of the displacement method.

Second part shows the possibility of using successive approximations for calculating stresses due to dynamic loads. The convergence of the iteration process is demonstrated for any type of structure. The demonstration is also valid for the case of static loads.

Third part presents a new method for calculating the first frequency of free oscillations.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4394. Kolesnikov, K. S., Interpretation of experimental curves of damped oscillations by I. Newton's method (in Russian), *Inzhen. sbornik* **20,** 164–167, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 114.

Newton's known theorem on the dependence of resistance to oscillating movement on the difference in length of the arc of two consecutive swings of a pendulum is reproduced in the exposition

of A. N. Krylov with some explanatory remarks by the author. The named theorem and its result are adapted for the mathematical study of records of damped oscillations. An example of the calculations is given. V. D. Kononenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4395. Hamilton, A. H., Mechanical vibration analysis by electrical circuit analogy, *GM Engng. J.* **5,** 2, 34-37, Apr.-May-June 1958.

During the design and development phase of a multi-cylinder diesel engine, torsional vibration problems must be solved to determine resonant frequencies and vibration amplitudes. The solution to these problems can be a complicated and wearisome matter, especially when more than two or three mass-spring systems are involved. To reduce the complexity and the tedious and time-consuming labor involved with such problems, the electromechanical analogy concept is applied. This analogy allows an engineer to think of mechanical systems in terms of electrical circuit theory. Electrical networks composed of capacitors, inductors, and resistors can be arranged and studied in lieu of mechanical networks composed of masses, springs, and friction elements. The validity of this analogy rests on the formal similarity of differential equations describing the mechanical and electrical systems being studied. The analogy theory, therefore, is a precise relationship established on a firm mathematical basis. The practical application of the theory allows a simple and inexpensive approach to the analysis and solution of a complex vibration problem. From author's summary

Wave Motion in Solids, Impact

(See Revs. 4362, 4459, 4542, 4585)

Elasticity Theory

(See also Revs. 4328, 4337, 4380, 4391, 4425, 4428, 4437, 4439, 4444, 4445, 4469, 4473, 4482, 4483, 4484, 4518, 4525, 4532, 4585, 4587, 4752)

4396. Manacorda, T., Relation between stress and strain in an incompressible body presenting reversible transformations (in Italian), *Boll. Un. mat. Ital.* **12,** 3, 1-8, Mar. 1957.

The derived formulas involve the principal components of the strain tensor and the orientation of the axis of the strain tensor with respect to the fixed axis of reference. The relationships given are not dependent on the reference system, and the Lagrangian description is a special case of the more general treatment given.

The relationships are of the form:

$$t^b = -\rho \frac{\partial F_\Gamma}{\partial \Gamma_n} + q_a \frac{\partial D}{\partial \Gamma_n} \qquad b = 1, 2, 3$$

t^b are the components of the stress tensor, ρ is the specific gravity of the medium in the considered state, Γ_n are the components of the strain tensor, D is the Jacobian determinant of the coordinates of the initial configuration with respect to the final configuration, and q_a are the scalar multipliers depending on the incompressibility condition.

Using the derived relationships, author shows that the necessary and sufficient condition for the isotropy of the medium in the configuration of reference is the coincidence of the strain and stress tensor. C. A. Sciammarella, Argentina

4397. Thomas, T. Y., Deformation energy and the stress-strain relations for isotropic materials, *J. Math. Phys.* **35,** 4, 335-350, Jan. 1957.

Author considers problem of conditions under which the total energy E(kinetic plus deformation energy) in a deformable body is a scalar invariant function of the stress tensor, the strain-rate tensor, and the density. It is assumed that stress rate is expressed as a polynomial function of strain rate, stress, and density. This form, called the "preferred" form by author, is general enough to include cases of Prandtl-Reuss plastic flow equations, and linear elastic equations. Invariance of E, coupled with restriction of form of stress-strain law, results in certain permissible forms for E in terms of strain invariants, elastic constants, and other material constants, which must be interpreted through the form of the stress-strain law. When stress is small, linear elastic form results. H. J. Plass, Jr., USA

4398. Misicu, M., On the solving of spatial problem of elasticity theory. Applications to theory of plates, *Acad. Repub. Pop. Romane Rev. Mécan.appl.* **2,** 1, 1957.

Based on fundamental studies previously published, author presents the equations of elasticity theory with the aid of monogeneous functions of quaternions.

Indications are given concerning the solving of the problem of arbitrarily loaded parallelepipedic thick plates for various conditions of support.

Results are plotted in a diagram which allows one to obtain the bending modulus from the expression of maximum stresses ($\sigma = M/w$), depending on the plate dimensions; at the same time, the diagram makes possible a unitary classification of bars, thin plates, thick walls, and thick plates.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4399. Kammerer, A., Mechanical and optical anisotropy and mechanical properties of materials (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 378-383.

It is well known that an initially isotropic material becomes anisotropic when subjected to large strains. Author finds it logical to assume that this mechanical anisotropy and the optical anisotropy of transparent materials subjected to mechanical stresses are of the same origin. This assumption permits the establishment of photoelastic relations for large strains. These are generalized for the case of viscoelastic behavior of the solid. Certain experimental observations, confiming the relations deduced theoretically, are mentioned.

G. Herrmann, USA

4400. Prager, W., Elastic solids of limited compressibility (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5,** 205-211.

Paper is concemed with the mechanics of an isotropic elastic solid the density of which cannot exceed a given critical value regardless of the pressure. As long as the density remains below this critical value, the stress-strain law contains two elastic constants, the shear modulus and the bulk modulus. At the pressure that corresponds to the critical density by this two-constant law the solid becomes incompressible; for higher pressures the stress-strain law contains only one elastic constant, the shear modulus. The general boundary-value problem for this type of solid is formulated, the uniqueness of the solution is discussed, and associated extremum principles are established.

From author's summary by G. W. Housner, USA

4401. Kuranishi, M., Strains and stresses of continuous media in large deformations (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5,** 235-247.

To define finite strains, author adopts the rational procedure that the natural strains are formed by the integral sum of the current strain rates of each element of material. Then, for finite extension, the logarithmic strain results. The significance of rotation in the theory of deformation comes to light. It becomes necessary to specify this rotation as well as the change of orientation of the principal axis so as to express definitely the development of deformation. The stresses are referred to the current area of the deformed body. The state of stress and its change in the course of deformation are dwelt on in detail and also the deformation due to the prescribed loading development is discussed. The state of stress defined as the true stress is expressible as a tensor, but the state of finite natural strain does not generally constitute a tensor. In general, the finite principal stress axes do not coincide with the finite principal strain axes, even if the stress-strain relation is infinitesimally isotropic and linear.

From author's summary by K. Marguerre, Germany

4402. Teodorescu, P. P., On a method for approximating boundary conditions in case of plane problem of elasticity theory (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2**, 2, 1957.

An approximation method is suggested which has points in common with usual approximation methods, i.e., the variational and finite difference methods. It consists in looking for an analytical function of the simplest form which would verify boundary conditions at a finite number of points. This function gives the stress and strain state for each point inside the body. Calculation of difference between the stress state found and the loading on the boundary allows one to estimate the exactness of the results obtained.

By using biharmonical polynomials, author applies results to plane problem of elasticity theory and presents a complete example of computation.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4403. Galimov, K. Z., Some variations of formulas in the nonlinear theory of elasticity (in Russian), *Uch. Zap. kazansk. gos. un-ta* **115**, 12, 111–118, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 830.

Let $\mathbf{x}$ be the vector of spatial forces, $\mathbf{x}_{(n)}$ the vector of surface forces, referred to the unit of the original space v and surface s, u the vector of transfer, σ^{ij} the countervariational components of the stress tensor, referred to the unit of the original surface in the system of coordinates of the deformed space, $\epsilon_{\alpha\beta}$ the tensor of the end deformation, W the deformation energy, $F = F(\sigma^{ij})$ the complementary energy

$$F = \sigma^{\alpha\beta}\epsilon_{\alpha\beta} - W \qquad (\sigma^{\alpha\beta} = \partial W/\partial\epsilon_{\alpha\beta})$$

It is shown that if the variations of the tensors of stress and external forces do not disrupt the conditions of equilibrium and the statical boundary conditions, then the equation

$$\int_v u\cdot\delta\mathbf{x}dv + \int_s u\cdot\delta\mathbf{x}_{(n)}\,ds = \delta\int_v \left(F + \frac{1}{2\sigma}^{\alpha\beta}\nabla_\alpha u\cdot\nabla_\beta u\right)dv$$

(where the transfers vary as well) appears as a modified formulation of the conditions of continuity of end deformations. An expression is given for the stress tensor σ^{ij} satisfying the equations of equilibrium when spatial forces are absent. A specific case is examined of small deformations and moderate angles of rotation. Reissner variational formula is given in generalized form [E. Reissner, *J. Math. Phys.* **29**, no. 21, 1950] for the functional

$$P = \int_n \mathbf{x}\cdot u dv + \int_s \mathbf{x}_{(n)}\,u ds = \int_v (\sigma^{\alpha\beta}\epsilon_{\alpha\beta} - F)\,dv$$

where, in comparing, assumptions are permitted in regard to possible transfers and an arbitrary value for tensor σ^{ij}, while $\epsilon_{ij} = \epsilon_{ij}(u_k)$, $F = F(\sigma^{ij})$, by the conditions of the stationary state, appear as equations of equilibrium, statical, boundary and physical correlations $\epsilon_{ij} = \partial F/\partial\sigma^{ij}$.

N. A. Alumyae
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4404. Tchankvetadze, G. G., The symmetrical deformation of an elastic semi-space (in Russian), *Soobshch. Akad. Nauk GruzSSR* **17**, 1, 7–14; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3348.

The methods of N. I. Muskhelishvili are extended to the axially-symmetrical case for an elastic semispace with a cylindrical or spherical cavity. The equations of the boundary conditions are derived and the formulas of the common terms of the series, representing biharmonic functions. By this means, a finite expression of the stress function is found for the case of a concentrated, vertical force, applied at a particular depth.

N. A. Rostovtsev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4405. Suncheleyev, R. Ya., A method of solution of some boundary problems in the theory of elasticity (in Russian), *Nauch. zap. Lvovsk. politekhn. in-ta* no. 30, 3–14, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6820.

The elastic equilibrium of a transversely isotropic body is examined; i.e., of a body at each point of which the axis of elastic symmetry is of infinitely high order. It is further assumed that the body is inhomogeneous; that is, that its moduli of elasticity (of which there are five) depend on the coordinate y_3 counting in the direction of the axis of elastic symmetry.

All the equations, expressions, and conditions incorporated in the paper are written in matrix form. Author starts from the equations of equilibrium of a transversely isotropic body in displacements, investigates and transforms them, introducing new and unknown functions and the cylindrical coordinates r, φ, y_3, and determines their solutions in the form of series of the following construction:

$$W = \sum_{k=-\infty}^{\infty} e^{ik\varphi}\int_0^\infty J^{(k)}(\lambda r)\,X^{(k)}(y_3,\lambda)\,d\lambda$$

in which $X^{(k)}$ is a function satisfying systems of linear equations of the second order with variable coefficients, while $J^{(k)}$ is expressed by Bessel functions of the argument λr.

The functions of W thus determined are applied to the construction of a solution for two problems of the equilibrium of a transversely-isotropic semispace with an inhomogeneity of the kind indicated above, when the corresponding displacements and stresses on the surface are given. All the arbitrary constants included in the functions $X^{(k)}$ are determined from the boundary conditions.

S. G. Lekhnitskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4406. Martini, L., The problem of a circular ring under the action of internal and external hydrostatic pressure (in Polish), *Rozprawy Inż.* **5**, 4, 495–512, 1957.

Paper is devoted to the determination of the state of stress in a homogeneous circular ring under the action of internal and external hydrostatic pressure linearly variable along one of the diameters.

The solution is obtained using the complex variable. The influence of the weight of the ring on the stress distribution is taken into consideration. The results obtained are used for the determination of the state of stress in a thick-walled tube of finite length immersed in a liquid.

J. Mossakowski, Poland

4407. Smolovik, I. I., Application of Maxwell's stress functions for the solution of problems in the 3-dimensional theory of elasticity (in Russian), Avtorefer. diss. kand. fiz.-matem. nauk Tomskii un-ta Tomsk., 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 853.

4408. Ylinen, A., Solution of the problem of the pressure between two bodies in contact (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5**, 223–232.

The Hertz solution of the problem of contact of two elastic solids is obtained by assuming a semi-ellipsoidal distribution of pressure over an elliptical contact area and demonstrating by direct integration that the integral equation arising from the condition on the deflection is satisfied.

H. Deresiewicz, USA

4409. Raymondi, C., Stresses under combined bending of Saint-Venant's solids (in Italian), *Pubbl. Fac. Ing., Univ. Pisa* (*16*), no. 791, 23 pp.

Problem of combined bending of a Saint-Venant solid is basically solved by determining distribution of stresses statically equivalent to shear forces T and $-T$, and to the bending moment $M = -TL$, L being the length of the body, in such a way that $\sigma_x = \sigma_y = \tau_{xy} = 0$ in all points of the solid. This condition assumes that the Z-axis of the three-dimensional system is parallel to geometric axis of the solid. Author presents the solution under the assumption of arbitrary center 0 and the acting force parallel to y-axis. Displacement components are derived by superposition of a suitable rigid movement. Several observations are discussed with particular reference to general integration of the Saint-Venant problem. It is shown by direct integration of equations expressing the combined bending that it is not necessary to consider the classic conditions of center of the shear.

J. J. Polivka, USA

4410. Arutyunyan, N. Kh., and Chobanyan, K. S., Torsion of prismatic bars made up of various materials, with creep taken into account (in Russian), *Dokladi Akad. Nauk Arm SSR* **21**, 1, 3–9, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2230.

The problem is examined of the torsion of a heterogeneous prismatic bar with an arbitrary transverse section, consisting of two prismatic bars soldered along the surface of contact. The first bar possesses the property of creep in agreement with N. Kh. Arutyunyan's equation ["Some questions relating to creep," Moscow-Leningrad, Gostekhizdat, 1952]

$$\gamma_{xz}(t) = \frac{\tau_{xz}^{(t)}}{G_1} - \int_{\tau_1}^{t} \tau_{xz}(\tau)\,\frac{\partial}{\partial \tau}\,\omega(t,\tau)\,d\tau$$

where t is time, $\omega(t, \tau)$ is the measure of creep when pure shear is present, G_1 is the shear modulus; the second bar is elastic, i.e., $\gamma_{xz} = \tau_{xz}/G_2$, where G_2 is the shear modulus. It is shown that the functions of stress F_1 and F_2 satisfy the equations

$$\Delta F_i(x, y, t) = A_i(t) \quad (i = 1, 2)$$

where Δ is the Laplace operator, while A_1 and A_2 are unknown functions, depending only on time. On the contour of the bar $F_1 = 0$, $F_2 = 0$; along the soldered line

$$\frac{1}{G_2}\,\frac{\partial F_2}{\partial \nu} = \frac{1}{G_1}\,\frac{\partial F_1}{\partial \nu} - \int_{\tau_1}^{t} \frac{\partial F_1}{\partial \nu}\,\frac{\partial}{\partial \tau}\,\omega(t,\tau)\,d\tau$$

where ν is the normal to the soldered line. For the determination of functions $A_1(t)$, $A_2(t)$ and the torsion angle $\theta(t)$, use is made of the condition of static equivalence and two correlations, arising from the condition of complete bending of the bars.

L. M. Kachanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4411. Mitelman, L. M., Solution of the torsion problem by the method of successive approximation to the contour (in Russian), *Trudi MAI* no. 47, p. 92, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 846.

To begin with, generally known questions are stated: the problem of torsion in an elastic case and existing variation methods for its solution. An examination is made separately of the methods of Ritz, Galerkin, Trefftz, and Leibenzon's way of approximation. Then a solution is given of the torsion problem by the method of successive approximation to the contour, shown as a development of Trefftz method. This method permits the solving of the torsion problem in cases of multi-connected and not bulging zones and establishes the degree of accuracy of the solution. The solution of the problem is carried out in the stresses having the form of

$$\psi_n(x, y) = f_0(x, y) + \sum_{i=1}^{n} a_i f_i(x, y) \qquad [1]$$

where $f_0(x, y)$ is a function satisfying Poisson's equation, the remaining functions $f_i(x, y)$ being harmonics. Series ψ_n is examined as an accurate expression of the stress function ψ, but not for the region bounded by the given contour S, but for some other region on the contour S_n for which the boundary conditions are accurately satisfied. The solution of the problem represents in itself the determination of such a contour for S_n that would have a sufficient degree of likeness to the given contour S.

This gives the author the possibility of estimating the degree of accuracy of the solution. Coefficients a_i of series [1] are determined with the help of the following equations

$$\oint_S (\psi n - C_k) f_j\,ds = 0 \quad (j = 1, 2, \ldots, n)$$

where C_k are the constant values of the stress function on the closed contours. The author selects a system of stepped harmonic functions to illustrate its working in any given multiconnected region having i contours (out of which l are outer and $i - l$ are inner contours). The functions consist of i classes, of which l are classes of whole functions and $i - l$ of fractional functions, the specific point of each of which is put inside the portion of the plane, bounded by one or other (corresponding to that point) of the inner contour of the region. Finally, concrete examples of the torsion problem are examined, in cases of singly connected regions, to demonstrate the essential nature and sequences of the application of the method. As examples are given: a square section, a section having the shape of a semicircle, an isosceles right-angled triangle, and an aviation profile.

M. M. Manukyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4412. Oroveanu, T., On the torsion of notched rods of circular cross section (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2**, 2, 1957.

Paper concerns the torsion of a notched rod of circular cross section. Exact solution is given for a notched-to-the-center rod. By similar considerations, an approximate solution is obtained for the more general case of a notch which does not reach the cross-section center.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4413. Pronenko, A. A., The free torsion of compound metallic beams (in Russian), *Trudi Kharkovsk. in-ta inzh. zh.-d. transp.* no. 26, 197–212, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3616.

The free torsion is examined of compound metallic beams having a closed profile with solid and lattice sides. The lattice webs

are substituted by solid webs of equivalent shearing strength. The shear displacement of the median plane is determined for all sides of the closed section. It is assumed that the cross section of the beam does not experience deformation and that there is no loss of resistance in the components of the beam.

On the basis of suggested formulas, numerical examples are given for the calculation of compound beams working in free torsion.

The theoretical results obtained for three beams are compared with the experimental results obtained by the ONIPS. The rigidity values of the beam in torsion, $G(I_k + I_d)$, are correlated, the coincidence being satisfactory.

It is also shown that neglect of the work of the sides of the beam in shear gives exaggerated values for the rigidity of the beam. A. I. Strel'bitskaya

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4414. Madejski, J., Theory of similarity of thermo-elastoplastic phenomena (in Polish), *Rozprawy Inż.* **5**, 4, 481–492, 1957.

Paper contains a description of the similarity criteria for thermoelastic phenomena and equations describing the thermoelastic state of the body and the model.

Assuming that the body and the model are geometrically similar and loaded in a similar way, the conditions of equivalence of these equations are analyzed. These conditions reduce to those of constancy of certain quantities called criterion numbers.

In conclusion an example of application of the above criteria to model construction is described. P. Perzyna, Poland

4415. Bollenrath, F., Some remarks upon the problem of temperature shock in aircraft, *AGARD Rep.* 90, 12 pp., Aug. 1956.

Structural problems, particularly thermal shock, associated with nonuniform, transient temperatures in structural members are discussed in a general way and comments are made on the influence of factors such as material, design, and service conditions. The temperature distribution in a thick plate heated on one surface and cooled on the other by forced convection is calculated and the resulting thermal stresses determined for two types of restraint. Specific results of time required to reach a prescribed stress level in plates of various thicknesses made from three types of metals are presented. Comments on further theoretical and experimental study of the problem form the conclusion.

R. R. Heldenfels, USA

4416. Dubinskii, S. L., Rusanova, E. L., and Stoll, B. F., Calculation for anchor ring-shaped compensators for pipe conduits of low pressure (in Russian), *Sudostroenie* no. 5, 14–16, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2188.

Results are given for work carried out at the Kirovskii factory on the calculation and testing of a series of anchor ring-shaped compensators, intended for use for thermal expansion in a system of ships' gas conduits and air conduits of low pressure. Comparison of the computed and experimental data confirmed the high degree of precision of this method of calculation for anchor ring-shaped envelopes, developed by V. V. Novozhilov ["Theory of thin shells," Sudpromgiz, 1951]. V. N. Gusev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4417. Forray, M., and Zaid, M., Thermal stresses in a circular bulkhead subjected to a radial temperature distribution, *J. aero. Sci.* **25**, 1, 63–64 (Reader's Forum), Jan. 1958.

4418. Aga, M. S., Problem of temperature fields in the study of thermal elasticity for some bodies of cylindrical symmetry (in Russian), Avtorefer. diss. kand. tekhn. nauk Leningr. inzh.-stroit. in-ta, Leningrad, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 854.

Experimental Stress Analysis

(See also Revs. 4399, 4446, 4479, 4503, 4515, 4518, 4529)

Book—4419. Murray, W. M., and Stein, P. K., Strain gage techniques, Parts I and II, Cambridge, Mass., Massachusetts Institute of Technology, 1957, Part I–viii + 320 pp.; Part II–viii + 337 pp. $13.00 per set of 2.

These two volumes comprise the basic textbook material (and laboratory manual) to accompany a series of lectures on the use of wire strain gages as taught in special summer short-course programs by the authors. They include outlines of 10 laboratory experiments in Volume I and 16 in Volume II to accompany the course, and serve to illustrate practical application of the theory involved in the application and measurement of strains. The effects of temperature, gage factor settings, multiple-gage circuits, special types of dynamic measurements and use of gages in rosettes, torque meters, etc., may be studied experimentally with fairly simple equipment by following the procedures outlined. The approach to the subject is from the fundamental viewpoint of considering all factors that affect the resistance change of a gage as applied in a typical circuit, and an appraisal of the resistance change of the complete circuit from the viewpoint of accuracy and sensitivity as a strain-measuring system. Detailed analyses are made of instrumentation, mechanical and electrical aspects of the gage system, and the mathematics of various types of wheatstone bridges, potentiometer circuits, etc.

Excellent discussions are included of the characteristics of measuring systems and the response of electronic components such as amplifiers, recorders, etc., and the manner in which these influence the results obtained. Included also is a lengthy discussion of strain gage rosettes by types and methods of interpretation of the observations for appraisal of biaxial stress states.

These two volumes which the authors indicate are "notes not yet in final form" draw together in one place more detailed information on all phases of the selection, use, and interpretation of readings from electric resistance strain gages than is available anywhere else in the literature. In some respects the material is too minutely detailed and too complete for use by a beginner in the field. These books are excellent reference works for people with a background of experience who are actively engaged in strain-gage measurements; they would also be excellent references for students in experimental stress analysis who have the guidance of a capable teacher. Each chapter is well documented with extensive bibliographies listing basic studies in each area of the theory.

The authors have presented a very exhaustive treatise on every phase of the use of resistance-type gages for the measurement of strains in complex engineering structures.

T. J. Dolan, USA

4420. Legette, M. A., Strain-gage principles, *Instrum. and Automat.* **31**, 3, 447–449, Mar. 1958.

4421. Hathaway, C. M., Strain-gage instrumentation, *Instrum. and Automat.* **31**, 3, 450–454, Mar. 1958.

4422. Anonymous, Optical strain-gage standard, *Instrum. and Automat.* **31**, 3, p. 455, Mar. 1958.

4423. Stein, P. K., Sensitivity ratings for strain gages, *Instrum. and Automat.* **31**, 3, 456–459, Mar. 1958.

4424. Herczeg, L., and Beckman, P., High-temperature strain gages, *Instrum. and Automat.* **31**, 3, 460–461, Mar. 1958.

4425. Korsatevich, N. I., Ofengenden, R. G., and Kalina, P. N., Measuring of stresses in machine components (in Russian),

Nauch. tr. in-ta mashinoved. i s.-Kh. mekhan. Akad. Nauk, SSSR no. 5, 51-61, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2569.

The analytical treatment of the experimental determination of the stressed condition of any arbitrarily selected machine component for a sufficiently continued period of time included the sorting out of a large number of measured amplitudes according to size, and the determination of the static distribution of the amplitudes, characterizing the nature of the work of the component. The operative principle is described for the electronic apparatus used for the automatic calculation of the experimental values of the measured sizes. The apparatus, to start with, receives an electrical loading (stress) characterizing the range being measured. The apparatus automatically separates the stress applied into six sub-ranges, designed for transmitting a signal to the calculating apparatus, should that sub-range include an experimental size value. The calculating meters of each sub-range count the number of values, and, as soon as the test is concluded, the number of experimental values in a given sub-range is known at once. An example is given of the work on an arbitrary curve and determinations of maximum and minimum values. In the apparatus described electric meters were used, recording impulses of more than 1/25-sec duration, but it is possible to use meters recording impulses of 1/200 sec, and even more rapid than that. A brief description is given of apparatus of analogous type designed in the institute of structural mechanics of the Academy of Science, USSR. N. P. Raevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4426. Shikhobalov, S. P., Krasnov, V. M., Maksutova, T. D., Tsoitts, V. V., and Edel'shtein, E. I., Experimental investigation of the stressed condition of the blades of a water turbine (in Russian), Vopr. prochnosti lopastei vodyanoi turbiny, Leningrad, Izd-vo LGU, 1954, 174-216; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2436.

An account is given of the experimental investigation of the stresses in the blades of a water turbine when under the influence of an evenly distributed pressure on the working surface. The experiment was carried out by the method of photoelasticity with the application of "freezing" with subsequent sawing. The model was made of Bakelite by pouring Bakelite resin into a special mould, prepared from an easily fusible alloy. An even pressure was obtained by means of an assembly of small glass columns placed in a vertical position on the working surface of the blade. In determining the stresses of the edge effect, data were used from "the edge effect" in the Bakelite wedge having a thickness equal to the thickness of the feather of the blade, and subjected to the same temperature and other conditions as in the blade model, but not loaded with external forces. It was shown that, in the Bakelite used, the "edge effect" appears as the result of decomposition, that is, of the separation from it of the constituent substances, the basic water and phenol, and that it is possible to select such an external medium that the "edge effect" is not formed. Practical measures taken in the fight against "edge effects" included the immersion of the model in a mixture of water and glycerine and the covering of the model with a latex coating. The determination of the stressed condition of the blade was made using the formulas associated with the photoelastic method. Following on the results obtained, the deduction was made that the blade, investigated as a shell of variable thickness, is in the condition of pure momentary stress. Comparisons are also made with the solution of L. M. Kachanova.

V. M. Krasnov

Courtesy Referativnyi Zhurnal, USSR
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Rods, Beams, Cables, Machine Elements

(See Revs. 4337, 4350, 4410, 4413, 4449, 4456, 4462)

Plates, Disks, Shells, Membranes

(See also Revs. 4386, 4398, 4426, 4448, 4451, 4452, 4464, 4465, 4487, 4488, 4493, 4508)

Book—4427. Flugge, W., Statics and dynamic of shells [Statik und Dynamik der Schalen], 2nd ed., Berlin, Springer-Verlag, 1957, viii + 286 pp.,

The first edition of "Statik und Dynamik der Schalen" appeared in 1934. Since then, and particularly in the past decade, the advances in knowledge in the field of shell theory have been enormous. Prof. Flugge has skillfully incorporated most of the more important contributions of this period into this second edition.

The chapters are grouped essentially as in the first edition: (I) General theory, consisting of an exposition of linearized relations; (II) Membrane theory of shells of rotation, treating the general linear equations for this case, as well as considering spherical domes, spherical containers, toroidal shells, shells of uniform strength, conical shells, and shells in the form of hyperboloids of revolution; (III) Membrane theory of cylindrical shells, consisting of an exposition of general equations as well as applications to roof shells; (IV) Membrane theory of shells of arbitrary shape, including a derivation of the general linearized equilibrium equations, together with solutions of these equations for shells in the form of an elliptic paraboloid, a hyperbolic paraboloid, and a conoid; (V) Bending theory of circular cylindrical shells, consisting of a derivation of the linearized equations, a discussion of roof shell analysis, and the treatment of liquid containers of either constant or variable wall thickness; (VI) Bending theory of shells of rotation, presenting the linearized equilibrium equations, as well as applications to the bending of spherical and conical shells under various loadings, including thermal effects; (VII) Theory of prismatic shells, treating the bending of structures consisting of flat rectangular plates joined along the edges; (VIII) Stability of shells, comprising eigenvalue-type solutions for cylindrical shells subject to axial compression, radial pressure, or combinations of these loadings, and spherical shells subject to uniform external pressure. Small-deflection theory is employed almost exclusively, with only very brief mention of the numerous nonlinear treatments that have been presented within the past few years. Little mention is made of correlation of theory with experiment in this area. Lastly, Chapter (IX), Vibrations of rotationally symmetric shells, treats linear vibrations of cylindrical shells.

The book concludes with a rather comprehensive bibliography.

W. A. Nash, USA

4428. Catudal, F. W., and Schneider, R. W., Stresses in a pressure vessel with circumferential ring stiffeners, *Welding J.* **36,** 12, 550s-552s, Dec. 1957.

The solution of the problem is given by evaluating stresses in an exact manner, following the classical analysis of the edge displacements and slopes for various forces on cylindrical shells. The geometrical conditions give two simultaneous equations for M_0 (edge moment) and V_0 (edge shear).

A chart is presented for the determination of the maximum stress adjacent to the circumferential ring stiffener in terms of "stress ratio," which is the ratio of the total stress divided by the hoop stress in the unaffected part of the shell. A numerical example is given. A. M. Guzman, Argentina

4429. Reissner, E., and Sledd, M. B., Bounds on influence coefficients for circular cylindrical shells, *J. Math. Phys.* **36,** 1, 1-19, Apr. 1957.

This paper is concerned with rotationally symmetric deformation of a thin elastic circular cylindrical shell of variable wall thickness and of finite or semi-infinite axial length; one of the two edges of the shell is free, and the other, which is acted upon by a uniformly distributed bending couple M_0 and a radial force H_0, undergoes a radial displacement u_0 and a rotation β_0. With the assumption of linearity between stresses and strains it follows that

$$u_0 = -c_{uH} H_0 + c_{uM} M_0$$

or

$$H_0 = -k_{uH} u_0 - k_{\beta H} \beta_0$$

(and similar expressions for β_0 and M_0), where c and k are called "direct influence coefficients" and "inverse influence coefficients," respectively. Authors establish the upper and lower bounds for these coefficients by undertaking the "bounding of several such coefficients simultaneously"; this approach involves considerations which do not arise when only one influence coefficient is present in a given problem. As an example of the application of the inequalities derived, the case of a semi-infinite shell with exponentially varying wall thickness is considered in detail.

P. M. Naghdi, USA

4430. Beles, A., and Mihailescu, M., Equilibrium equations in oblique coordinates for shells of constant thickness (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2,** 2, 1957.

The first part of the paper deals with a direct method for deducing the equilibrium equation in oblique coordinates for shells of constant thickness.

The second part discusses the forms taken by the equilibrium equation system when analytically transcribed in various steps of approximation.

Staff, Revue de Mecanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4431. Immerman, A. G., Calculation for an orthotropic round cylindrical shell with transverse loading (in Russian), Calculation for spatial constructions, no. 3, Moscow, Gos. izd-vo lit. po str-vu i arkhitekture, 1955, 323-373; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2181.

An approximate solution is examined for the problem of calculating (the stresses) of a thin round cylindrical shell strengthened by ribs. In the presence of the ribs the shell is taken to have a different reduced thickness in the longitudinal and circumferential directions. The calculation resolves itself in two stages. In the first stage are determined the stresses in the shell on the basis of the validity of the elementary theory. The shell is, in this case, examined as a hollow beam, subjected to deflection and torsion. In the second stage a system is sought of supplementary self-balancing stresses, capable of being determined from the condition of the minimum potential energy of the shell. This system the author builds up from the normal stresses σ_x acting in the transverse sections of the envelope, and the tangential stresses and circumferential forces corresponding to them. The unknown σ_x are taken in the following form:

$$\sigma_x = \sum_2^n \sigma_{xn} \cos n\beta + \sum_2^n \sigma'_{xn} \sin n\beta$$

Further, a simplified expression is constructed to express the potential energy of the shell (without regard to the energy of shear and tension-compression in the circumferential direction). The corresponding Euler equation, serving as a means of determining functions σ_{xn}, has the form:

$$\sigma_{xn}^{IV} + 4\psi_n^4 \sigma_{xn} = \epsilon_n \Phi_n''$$

This equation is integrated for various forms of loading, applied to the shell. Formulas for calculations and tables are prepared for various cases important in practice. A more precise differential equation for the problem is deduced and integrated, the basis being a fuller expression for the potential energy of the shell. By comparing the results, the accuracy and the limits of applicability of the approximate solution are investigated. Numerical examples are examined. It is worthy of note that the use in the calculations of shells of the elementary solution first, then making them more precise by addition of self-balancing stresses, determinable from the condition of minimum potential energy, was proposed by Kh. Kh. Lanle [*Tr. Tallinsk. politekhn. in-ta* (*A*) no. 33, 1949], who, however, introduced some supplementary simplifying assumptions.

L. S. Gil'man

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4432. Isanbaeva, F. S., Determination of the lower critical loading of a cylindrical shell under compression from all sides (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, ser. fiz-matem. i tekhn. nauk* no. 7, 51-58, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 863.

An examination is made of the large deflections of a closed round cylindrical shell under compression from all sides by a normal external pressure. It is assumed that on its faces the shell is strengthened by ribs, inflexible to bending in their own plane. Ritz's method is applied; the deflections assume the form

$$w = f_1 \sin\alpha \sin n\beta + f_2 \sin^2\alpha \qquad [1]$$

where $\alpha = \pi x / a$, $\beta = \pi y / b$, n a whole number, x a coordinate reckoned along the pattern from the rib, y a coordinate along the arc, a the length of the shell, $b = \pi R$; R the radius. The full energy of the system exhibits variations along three parameters, which include the values f_1, f_2, and n. The lower critical pressure is determined; it is shown by means of numerically calculated examples how the dimensions of the shell affect the relation between those values and the upper critical pressure, determined by Mises' formula. The lower boundary approaches the upper, both for sufficiently long and for very short shells.

The equation on page 52 of the paper

$$\int_0^{2b} \frac{\partial y}{\partial y} dy = 2b\epsilon_\omega \qquad [2]$$

(v transposition along the rib, ϵ_ω deformation of elongation of the axial line of the rib) appears to be inaccurate. In conditions of periodicity it should be

$$\int_0^{2b} \frac{\partial y}{\partial y} dy = 0 \qquad [3]$$

As $\epsilon_\omega = 0$ is taken to be its furthest limit, all subsequent computations correspond to equation [3].

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4433. Soare, M., Membrane theory of thin shells with double parabolical directrix and directrix plane (in German), *Acad. Repub. Pop. Romane, Rev. Mécan appl.* **2,** 1, 1957.

Proceeding from known general formulas which determine stresses in thin shells having as their middle surface a surface with double directrix and directrix plane, all integrals are evaluated for the case of a parabolical directrix and loads due to dead weight, snow, and wind.

Discussion includes qualitative discussions on the stress state in thin shells.

Staff, Revue de Mecanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4434. Visarion, V., On a method for solving the problem of thin shells, *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2,** 2, 1957.

Author presents a general method for solving the problem of thin shells, as well as some results he attained.

By using the static-geometrical analogy, the system of equations is reduced to a single equation having the complex stress as unknown

$$E = (N_\alpha + N_\beta) + i\sqrt{\frac{1-\mu}{1+\mu}\frac{3}{b}}(M_\alpha + M_\beta)$$

where α and β stand for the lines of curvature. The method may be readily applied to surfaces which may be conformably transformed on a sphere referred to principal lines having equal lengths of the arc elements. For some of these surfaces, the geometric coefficients of which are functions of a single variable, author reduces the problem to the study of ordinary equations by using Fourier series.

Method is extended to the case of asymptotic coordinates and applied to helicoidal shells.

Staff, Revue de Mecanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4435. Szolegowsky, F., The extension of an infinite disc with a circular ring of different elasticity (in Russian), *Byul. Polsk. Akad. Nauk Otd. (IV)* **3,** 2, 81–85, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3369.

Solutions are given of two particular cases of elastic equilibrium of an infinite, isotropic plate with a welded, circular ring of another isotropic material. In the first case, the stresses are assumed to be normal and uniformly distributed along the inner edge of the ring, while at infinity, the forces vanish. In the second case, the inner edge of the ring is not loaded, and the plate is extended in one direction by uniformly distributed stresses acting at an infinitely long distance from the ring.

The problems are treated as two-dimensional and solved by known methods. The solutions given in the paper are not new [cf. G. N. Savin: "The stress concentration at holes," Gostekhizdat, 1951, pp. 286–306]. S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4436. Mirtskhulava, Ts. E., Computations for rigid rectangular plates on an elastic foundation (in Russian), *Trudi Gruz. n.i. in-ta gidrotekhn. i melior* **3,** 16, 216–232, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2197.

An approximate method is indicated for computations for rectangular plates resting on an elastic semispace, the longitudinal sides of which are fastened or freely supported on rigid supports, while the transverse sides can be subject to any arbitrary conditions. In particular, the transverse sides can be freely supported or fastened. The principle of distribution of reactive pressures is taken as known and is applied in the form of a polynome [see M. I. Gorbunov-Posadov, "Beams and plates on an elastic foundation," Stroimashizdat, 1949]. The problem merges with the finding of the deflection from the differential equation for deflection by Sofi Zhermen, with the solution of which the finding of the minimum of some double integral is linked. The function of deflections is presented in the form $\omega = f(x_1)F(y_1)$ where $F(y_1)$ is a known function satisfying the boundary conditions of a fastened edge when $y_1 = \pm b$, while function $f(x_1)$ satisfies from the condition of the conversion of the already mentioned determined integral into the minimum-differential equation of Euler. Values are assigned for the deflections, bending moments, transverse forces and torsion moments of a square plate and for the deflections of a rectangular plate. As a check calculation, the case is investigated of an evenly loaded square plate without an elastic foundation, in which all four edges are fastened. The value of the deflection in the center of the plate, calculated by the author, agrees accurately with the solution given by Timoshenko [Plates and shells, Gostekhizdat, 1949].

A. G. Ishkova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4437. Dmitriev, A. D., Approximate solution of the problem of evaluating the axial symmetrical stress of an infinite plate on an elastic foundation (in Russian), *Trudi Saratovsk. avtomob. dor. in-ta* no. 13, 25–50, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 901.

An approximate solution is submitted for estimating the action of a concentrated stress on an infinite plate on an elastic foundation. The reactions of the elastic foundation are taken to be proportional to the plate deflection. The bent surface of the plate, due to the action of force P, the point of application of which is assumed to be beyond the beginning of the coordinates, is expressed approximately as:

$$w_x = w_0(1 + 4x - 5x^2)e^{-4x}$$

where w_0 is the deflection due to the force and x is a nondimensional coordinate, equal to the ratio r/a—the distance r, from the beginning of the coordinates to any point at the distance a, from the same origin to the first point with zero deflection. The values of w_0 and a are determined from the condition of minimum potential energy of an elastic system and condition of equilibrium. Further calculations of the deflection moments are carried out by known formulas and offer no difficulties. Comparison of the results of such a calculation with the results of a strictly accurate calculation is proof of the satisfactory nature of the approximate solution. A case is investigated of an evenly distributed load on the circular platform, utilizing the superposition method.

P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4438. Reissner, E., Finite twisting and bending of thin rectangular elastic plates, *J. appl. Mech.* **24,** 3, 391–396, Sept. 1957.

An exact solution of the nonlinear differential equations for finite deflection of thin elastic plates is obtained for a rectangular plate under the simultaneous action of twisting moments T and bending moments M on two opposite edges. Relations are deduced between T and M on the one hand, and the angle of twist per unit length θ, and the curvature κ on the other. These relations represent a generalization of previously known results when either $\kappa = 0$ or $\theta = 0$. P. M. Naghdi, USA

4439. Winslow, A. M., Stress solutions for rectangular plates by conformal transformation, *Quart. J. Mech. appl. Math.* **10,** 2, 160–168, May 1957.

Muskhelishvili's complex variable method for solving two-dimensional stress problems by conformal transformation to the unit circle is modified by the author in that he splits the solution into two parts. One part of the solution is an exact polynomial solution for selected polynomial terms in the boundary forces which satisfy the boundary conditions directly. The solution for the remaining terms in the boundary forces is obtained by use of conformal transformation to the unit circle. In the case of rectangular plates, the mapping function is an infinite series so that author approximates this part of the solution by using a finite number of terms in the series. Numerical results are given for a square plate and a two-by-one rectangular plate under parabolic tension stress on the ends, using about seven terms in the series. Author discusses bounds for the approximations for the slow and irregular convergence of the series.

B. E. Gatewood, USA

4440. Wysiatycki, K., A problem of the infinite slice (in Polish), *Rozprawy Inż.* **5**, 4, 549–569, 1957.

An infinite cantilever plate whose edges are a straight line and a circle is considered. To solve the problem stress functions expressed in bipolar coordinates are used. The cases considered are those of the cantilever plate loaded by a moment, a vertical and a horizontal force acting at the end, a uniform load distributed along the upper, rectilinear, and the curvilinear edge and by a variable normal and tangential load along the curvilinear edge. Some of the results are obtained in the form of known functions. The examples are illustrated with stress diagrams.

J. Mossakowski, Poland

4441. Sapondzhyan, O. M., Deflection of an elliptical plate (in Russian), *Izv. Akad. Nauk, Arm SSR, Ser. fiz.-mat., estest. i tekhn. nauk* **7**, 5, 19–43, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2157.

Relying on the known analogy between the plane problem of the theory of elasticity and the bending of thin plates, author solves three particular cases of bending of a thin elliptical plate, fastened along its edges, making use of the known solution by N. I. Muskhelishvili of the first problem in the theory of elasticity for elliptical plates [N. I. Muskhelishvili, "Some fundamental problems in the mathematical theory of elasticity," Izd-vo Akad. Nauk, SSSR, 1954]. The following forms of loading the plate with evenly distributed loads were examined: on the plane of the cofocal ellipse, on the plane of the ring, and on the plane of the large axis of the plate. For these forms of loading author utilizes his previously published individual solutions [*Sbornik trudi Erevansk. politekhn. in-ta* no. 3, 1948]. There are misprints; in particular, in formula (3.2) one item has been omitted.

M. P. Sheremet'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4442. Kozhevnikova, V. N., The stress distribution on the contour of a rectangular opening in the bending of an infinite plate (in Russian), *Zap. Leningr. gorn. in-ta* **33**, 3, 90–98, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3380.

Detailed calculations are made of the stresses on the contour of a rectangular opening in an infinitely-extending plate exposed to bending in its own plane by a moment M. In the calculation, author retains in the representative plane

$$\omega(\zeta) = \frac{c}{\zeta} + \sum_{0}^{n} C_\nu \zeta^\nu$$

terms of the ninth order of ζ.

M. P. Sheremet'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4443. Kulik, A. N., The stress concentration at a circular cutout reinforced by a thin, elastic ring (in Russian), *Dopovidi ta providomleniya, Lvov Univ.* **6**, 2, 87–92, 1955; *Ref. Zh. Mekh.* 3, 1957, Rev. 3368.

Author determines the stress condition in an isotropic plate with a circular cutout reinforced by a thinning of constant cross section, on the assumption that at infinity the stress condition of the plate can be represented by a polynomial of n order with reference to the variables x and y.

Author analyzes as a particular case a beam with a sufficiently small, reinforced circular hole, loaded in pure bending or acted on by a constant, transverse force. I. A. Prusov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4444. Vorob'ev, L. N., Solution of a plane problem in the theory of elasticity for a rectangular orthotropic plate (in Russian), *Nauch. tr. Novocherkask. politekhn. in-ta* **26**, 120–131, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2147.

A flat beam, whose length is considerably greater than its width, is subjected to examination. The beam bends under the action of a continuous load, distributed along its top surface. The solution of the problem of the stressed condition of such a beam is obtained by the method of successive approximations. For the zero approximations stresses are accepted determined by means of the theory of resistance of materials. Then the author determines the first approximation for the components of stress σ_x from the equation of deformation, while the components of stresses σ_y and τ_{yx} are determined from the equation of equilibrium. Further along, the second approximation for σ_x is ascertained from the equation of deformation and the second approximation for σ_y and τ_{yx} from the equation of equilibrium, and so on. In so doing, the boundary conditions on the long sides of the beam are precisely satisfied, while on the short ones, approximately (in the integral sense). If the load of bending is presented in the form of a polynome, then the proposed method results in an accurate solution of the problem. A. S. Kosmodamianskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4445. Mossakowski, J., The state of stress and displacement in a thin anisotropic plate due to a concentrated source of heat (in English), *Arch. Mech. stos.* **9**, 5, 565–577, 1957.

In the first part of the paper a solution for a plane state of stress due to the action of a steady-state heat source in an anisotropic infinite plate is obtained. The system consisting of two heat equations and Airy's equation generalized to the case of thermal distortion is reduced to one differential equation of the sixth order.

$$\prod_{k=1}^{6} \left(\frac{\partial}{\partial y} - \mu k \frac{\partial}{\partial x} \right) \Phi = \frac{W}{b k_{22}}$$

The constants μ_1^1 and μ_3 depend on the coefficients of heat conduction $k_{kj}(i, k = 1, 2)$ and $\mu_1, \ldots, \mu_6$ on the coefficients of elasticity $a_{ik}(i, k = 1, 2, \ldots 6)$ where W denotes the intensity of the heat source.

The solution for an infinite plate constitutes the starting point for obtaining the solution for a thin semi-infinite plate. Four particular cases are considered: of free and clamped edge with constant temperature or with thermal insulation along the rectilinear edge. W. Nowacki, Poland

4446. Tenny, V. P., Experimental determination of the stiffness of rubberized-cloth membranes (in Russian), *Automation and remote Control* **17**, 11, 1042–1045, 1957 [Translation of *Avtomatika i Telemekhanika* **17**, 11, 1171–1175, Nov. 1956. Copies obtainable from Consultants' Bureau, Inc., New York City.]

Paper examines the variation in the stiffness of elastic membranes made of rubberized cloth when the initial load or pressure acting upon them is varied. In designing such membranes, which are utilized in various automatic control units, this variation in stiffness attains a considerable magnitude.

From author's summary

Buckling Problems

4447. Reinitzhuber, F., Formulas for the buckling of columns with linearly variable axial loading (in German), *Tech. Mitt. Krupp.* **15**, 8, 226–230, Dec. 1957.

Paper consists primarily of five numerical examples of the application of approximate formulas proposed by the author else-

where [AMR **8** (1955), Rev. 387] for the design of steel columns loaded as in the title under various end conditions. The results are compared with those obtained by the German Industrial Standard (DIN) 4114. For the inelastic range, in one example, author's procedure gives an allowable load 14% higher than allowed by DIN 4114. W. R. Osgood, USA

4448. Hoff, N. J., Buckling at high temperature, *J. roy. aero. Soc.* **61,** 536, 756–774, Nov. 1957.

Author surveys the influence of temperature and temperature gradients on a wide range of problems in buckling of columns, plates, and cylindrical shells. Included is an excellent bibliography of recent work in this area. The effort is logically divided into elastic buckling but with temperature reduced moduli and creep buckling. Elastic buckling is discussed both with load stresses and thermal stresses, and includes analyses of flat plates and cylindrical shells. Reduced torsional stiffness and torsional buckling of flat plates is also considered. Creep buckling is discussed within the framework of author's own effort on columns under axial load and cylindrical shells under constant bending moment. The cross-sectional flattening (Brazier) mode is considered for the shells, and some experimental results presented. An appendix contains complete derivation of author's analysis of creep collapse of cylinders. J. E. Duberg, USA

4449. Sonntag, R., The stability of a rotating shaft under bending load (in German), *Forsch. Geb. Ing.-Wes.* **23,** 6, 214–227, 1957.

Paper describes the behavior of a curved rotating (nonelastic defotmation) shaft situated in bearings. The centerline of the shaft and the axes of the bearings are co-planar and coincide in the points of contact. Author shows that the moment required for rotation of this shaft varies with the angle of rotation and derives formulas for its calculation and determination of the stability against buckling. Practical application of this phenomenon is shown on a safety device for an eccentric press for limiting the maximum allowed pressure. In the conclusion a note is devoted to the flexible shaft, which, though working under similar conditions, does not present the behavior described above, due to initial elastic deformation. V. Kopriva, Czechoslovakia

4450. Kempner, J., Stability equations for conical shells, *J. aero. Sci.* **25,** 2, 137–138 (Readers' Forum), Feb. 1958.

Stability equations for conical shells of circular cross section are deduced by the author from those obtained by Vlasov for stability analyses of arbitrary thin-walled shells of constant thickness. It is assumed that the stress system prior to buckling is governed by membrane equations for conical shells.

A. M. Sengupta, India

4451. Reynolds, T. E., A graphical method for determining the general-instability strength of stiffened cylindrical shells, *David W. Taylor Mod. Basin Rep.* 1106, 15 pp., Sept. 1957.

The results of numerical calculations of the general-instability strength of ring-stiffened circular cylinders are presented in graphical form. The calculations are based on Kendrick's "second solution," which is published in Naval Construction Research Establishment Report 244 (Part III). The collapse pressures from these graphs agree within 10% with those computed by Kendrick's theory throughout the normal range of submarine geometries.

From author's summary

4452. Terebushko, O. I., Stability and performance after loss of stability of cylindrical panels under compression and reinforced by ribs (in Russian), *Izd. Akad. Nauk. Latv. SSR,* no. 1, 111–130, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2177.

The stability of thin cylindrical panels reinforced by a set of elastic ribs arranged lengthwise was examined. The panel rests freely along its four edges on a rigid rectangular contour (base). To the round edges, able to move parallel to each other, are applied compression stresses formed in parallel. The longitudinal edges of the envelope, resting on the intermediate longitudinal ribs, can slide freely along them. The intermediate longitudinal ribs are elastic (their deflection, compression and torsion is taken into account), the edges of the envelope are rigid. Ritz' method is utilized. The given approximate function takes two forms:

$$W_I = f_1 \sin\frac{\pi x}{a}\sin\frac{\pi x}{b} + f_2 \sin\frac{n\pi x}{a}\sin\frac{i\pi y}{b} + f_3 \sin^2\frac{n\pi x}{a}\sin^2\frac{i\pi y}{b}$$

$$W_{II} = f_1 \sin^2\frac{\pi x}{a}\sin^2\frac{\pi y}{b} + f_2 \sin\frac{n\pi x}{a}\sin\frac{i\pi y}{b} + f_3 \sin^2\frac{n\pi x}{b}\sin^2\frac{i\pi y}{b}$$

where f_1, f_2, f_3 are constants; a and b are the sides of the plate; x and y the axis and peripheral coordinates of the central surface of the plate. A system of cubic equations was obtained for the determination of the parameters of the deflection of the envelope when being deformed beyond the limits of stability, and a calculation was carried out for the lower critical stress p^* of the envelope. An analysis was made of the influence of the accepted forms of deflection on p^*. A number of practical directions are given for estimating the influence of the reinforcing ribs on the performance of the envelope, and also formulas for p^* in envelopes of different curvatures. G. G. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4453. Rockey, K. C., Web buckling and the design of webplates, *Struct. Engr.* **36,** 2, 45–60, Feb. 1958.

Paper presents general conclusions obtained from studies of load-carrying capacity of steel and light-alloy plate girders. Proposed design procedure recommends that when buckling stress is below allowable stress for the material, web plates should be designed to operate in postbuckled range. Extent to which web may be loaded may in certain cases be controlled by aesthetic rather than strength considerations. K. S. Pister, USA

Joints and Joining Methods

(See Rev. 4506)

Structures

(See also Revs. 4392, 4415, 4417, 4440, 4448, 4453, 4474, 4508, 4509, 4526, 4568, 4569, 4571, 4785, 4786)

Book—4454. Charon, P., The Cross method and practical calculations of statically indeterminate structures [La méthode de Cross et le calcul pratique des constructions hyperstatiques théorie et applications], 2nd ed., Paris, Eyrolles, 1955, xi + 303 pp. (paperbound)

Book is one of the most comprehensive works on the Cross method for the solution of statically indeterminate structures. Divided in four main parts, it encompasses structures with straight members of uniform cross sections; with straight members and variable cross sections; with curved members; and finally, skyscraper-type structures.

The general theoretical foundation of the method is derived from Bresse's equations. The extensions of the method by Grinter, Zaytzeff, Kammuller and Cocchi are included. The book does not give a critical evaluation of the methods, but it shows

their particular advantages and fields of application. The construction of influence lines is also discussed.

The procedure employed in calculations uses the tabulating method, which can very easily be adapted to calculator work. An ample number of numerical examples follows each chapter and elucidates quite considerably the practical adaptability of the particular procedures. D. Vasarhelyi, USA

4455. Hellan, K., Jr., Rotation moments in continuous structures (in Norwegian), *Tekn. Skr.* no. 18, 44 pp., 1958.

4456. Chronowicz, A., Frames with curved beams, *Concr. constr. Engng.* **52,** 2, 377–389, Nov. 1957.

4457. Simpson, H., Design of folded plate roofs, *Proc. Amer. Soc. civ. Engrs.* **84,** ST 1 (*J. Struct. Div.*), Pap. 1508, 22 pp., Jan. 1958.

4458. D'yakov, M. Ya., Influence of "above arch" structure on the stability of an arch (in Russian), *Trudl Leningr. in-ta inzh. vod. transp.* no. 22, 33–34, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2313.

Using the method of deformations a determination is made of the critical loading of a compressed arch of "above arch" structure, the supports of which are rigidly joined to the arch. Examinations were made of six- and ten-panelled hingeless arches and of a six-panelled double-hinged arch. The loads are made to converge with the joints of the "above arch" structure; together with this, the arch is replaced by a broken rod. Indications are given for some simplifications in the calculations, nevertheless these remain unwieldy and complicated. Some results (obtained for the calculations) are given of the cipher characterizing the influence of the rigid joining of the supports of the "above arch" structure on the size of the critical arch-loading. Here, the separate deductions put forward during this formulation are inaccurate and may lead to misunderstandings (for instance, the assertion that the "above arch" structure may either increase or decrease the stability of the arch). A. A. Pikovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4459. McKee, K. E., and Sevin, E., Design of masonry walls for blast loading, *Proc. Amer Soc. civ. Engrs.* **84,** ST 1, (*J. Struct. Div.*), Pap. 1512, 12 pp., Jan. 1958.

Authors calculate the response of a masonry beam constrained between rigid supports at the ends and loaded head-on by blast. It is assumed that the strength of the beam arises from the arching action between the supports. The results which are in excellent agreement with experiments, permit either the design of a wall for a given loading or the determination of the maximum permissible load of a given wall. Theory is extended approximately to wall panels supported on four sides.

M. Kuipers, Holland

Book—4460. Sachnowski, K. W., Reinforced concrete structures [Stahlbetonkonstruktionen], Berlin, VEB Verlag Technik, 1956, 846 pp.

This is the German translation of a comprehensive Russian textbook, the first edition of which appeared in the thirties. Book mainly rests upon research work done in USSR: elaborate comments and quotations by the German editor, however, establish desirable connection with research and practice of other countries, especially Germany. Almost all specialities of the past decades are discussed in great detail; also many specifications, recommendations, etc., are quoted, which enable the designer to profit by recent investigations. Thus, obligatory regulations concerning plastic design of reinforced concrete cross sections of any shape under bending and/or normal force as well as shear have existed since 1938; hereby, the safety factors involved are derived from probabilistic considerations. Limit analysis of the structure as a whole (redistribution of moments), however, is only briefly mentioned. It is also interesting to learn that, since 1937, instructions exist for design of shells—cylindrical as well as prismatic (Faltwerke)—in which a thorough simplification of the whole theory is given.

Although reviewer does not agree with all opinions expressed in this textbook, he considers it to be one of the most up-to-date, the study of which would be useful to anyone dealing with reinforced concrete. H. Craemer, Germany

4461. Zlockovic, D., Example of a large-space structure in reinforced concrete and its analysis (in Croatian-Serbian), *Nase Gradevinarst vo* **12,** 1, 42–45, Jan. 1958.

A structure spanning 150 ft, 42-ft clearance with long overhangs and balconies was designed by the author for the Belgrade Fair. In this connection, various structural types were investigated as to their illumination, economy, and other conditions. The effect of butterfly shape frames, spaced 30 ft, and natural illumination through slightly curved roof surfaces and vertical glass walls is a valuable contribution to the aesthetics of the building. Structure was built with following quantities of materials: per sq ft: 3.3-cft concrete, 4.6-lb steel. Six different schemes were investigated (and are described and illustrated) as to their functionalism, especially technological process and construction method, natural illumination, foundations, and other functions such as heating, ventilation, etc. J. J. Polivka, USA

4462. Yakobson, K. K., The effect of temperature and shrinkage of concrete on the united section of a metallic beam and a ferro-concrete slab (in Russian), *Trudl Novosibir. in-ta inzh. zh.-d. transp.* no. 11, 323–330, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1172.

A determination is made of the temperature and shrinkage stresses in beams of T section, the shelves of which are in ferro-concrete slabs and the walls in metal. Formulas are given for ascertaining the stresses in the slab and in the wall, while considering the effect of creep in the cement. The temperature is assumed to be constant, while the extent of shrinkage and creep is taken to follow the exponential principle. Numerical examples are given. M. A. Zadoyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4463. Harder, N. A., Shear reinforcement in a girder of a prestressed concrete (in Danish), *Bygnsstat. Medd.* **29,** 1, 24 pp., May, 1958.

4464. Smyth, W. J. R., Designing a slab using the fracture line theory, *Civ. Engng. Pub. Works, Lond.* **53,** 620, 163–167, Feb. 1958.

4465. Lapajne, S., Restraining conditions of large bridge slabs of reinforced concrete supported by heavy continuous edge girders resting on columns (in German), *Gradbeni Vestnik* **8,** 47/50, 123–127, 1956/57.

4466. Hacker, J. C., A simplified design of composite bridge stringers, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 6 (*J. Struct. Div.*), Pap. 1432, 7 pp.

Paper gives an equation for an approximate design of balanced composite steel stringers minimizing the amount of work for the designer in selecting the trial section. Author states that the rigorous mathematical expression "is involved and dependent upon so many variables that its use in the design office is im-

practical." He therefore presents a working formula which yields good results within a certain range. Examples are given.

L. N. Persen, Norway

4467. Verigin, K. P., Endurance of cement-fabricated members when exposed to two-dimensional compression (in Russian), *Trudi Khar'kovsk. inzh.-stroit. in-ta* no. 4, 113–119, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1345.

An experimental determination was completed on cement cube test pieces 12 × 12 × 12 cm when subjected to two-dimensional compression. The experiments showed an appreciable increase in the endurance of the cement by comparison with the usual single dimension compression, attaining 2.4 times as much. The degree of increase of strength of the cement depends on the specifications for the test, the relation of the stresses in both directions, and the endurance of the actual cement used.

Z. A. Atsagortsyan

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4468. Vainberg, D. V., Popkov, V. G., and Umanskii, E. S., Initial stresses in composite (built-up) wheels (in Russian), *Sb. tr. in-ta stroit. mekh. Akad. Nauk USSR* no. 20, 73–95, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1229.

This is an approximate method of determining the stresses when putting together composite wheels with spokes. For wheels with a slotted nave there are forces, evoked by the fitting of the tire, on the wheel center and forces from the clamping of the ring on the hub. The formulas obtained are also utilized for calculation of the initial stresses in a wheel with an unslotted nave. A numerical example is given of the calculations of stresses in the body of a composite wheel, with a slotted cast iron hub, steel tire, and six spokes.

Yu. P. Girgor'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4469. Hayashi, T., and Akasaka, T., Experiments and analysis on the elastic properties of the sweptback wing plates (in Japanese), *Trans. Jap. Soc. mech. Engrs.* **5**, 42, 4–11, July 1957.

Authors analyzed the elastic deformation of 30° sweptback cantilever parallelogram plate with constant thickness, using the method developed by Reissner et al [E. Reissner and M. Stein, "Torsional and transverse bending of cantilever plates," *NACA TN* 2369; AMR **4** (1951); Rev. 4410], the deflection function $w(x, y)$ being assumed as $w = f(x) + g_1(x)y + g_2(x)y^2$, where y is taken in chordwise direction. The experiments on a plate of span chord ratio 3.6, thickness ratio 2.42% were done under simple torsional or concentrated vertical load. The stress distribution and deflection curves are given fully in figures. Agreement between the analysis and experimental results is good.

M. Kuranishi, Japan

4470. Morley, L. S. D., Determination of the stress distribution in reinforced monocoque structures. II. A theory of swept wings where the ribs are in the line of flight, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2967, 39 pp. + 24 figs., 1957.

Interesting method of estimating the stresses within a range of two or three chords caused by root constraint in a two-spar swept wing of reinforced monocoque construction where the ribs are parallel to the line of flight. The top and bottom surfaces consist of skins reinforced by numerous stringer lying parallel to the spars.

The method is not applicable to a wing with very thick skins and few or no reinforcing elements. In such a case the stresses caused by root constraint must be determined by more exact methods.

The general scheme of the analysis develops the fundamental equations that govern the stresses, strains and displacements in the separate components. Then, by comparison of displacements along their intersections, equations of compatibility are formed. The solution of these equations yields the stress distribution and the distorted shape. In deriving the fundamental equations for the skin-stringer combination, use is made of an oblique system of coordinates and stresses.

A suggested numerical procedure is given for evaluating the stress distribution and distorted shape. It is found convenient to use matrices, and the procedure has been so planned that the elements of a matrix are obtained by simple operations on the elements of preceding matrices.

Tests on a cellulose-nitrate model have provided good qualitative confirmation of the theory.

Specialization of the equations for the unswept wing verifies that the fundamental equations for the skin-stringer combination agree with those developed in Part I of same title.

From author's summary by K. Arnstein, USA

4471. Reddaway, J. L., An experimental investigation of the effect of engine loads on wing structures, *Aero. Res. Counc. Lond. Rep. Mem. 3062*, 7 pp. + 1 table + 12 figs., 1957.

Three cellulose-nitrate model wings, identical except for rib flexibility, have been tested under conditions reproducing typical engine loads. Stress distributions have been found experimentally by means of electrical resistance strain gages. The distribution due to an abrupt change of torsion has been compared with a theory by Williams, and that due to an abrupt change of shear with a theory by Taylor.

Local stresses at the engine nacelle are found to be appreciably higher in practice than would have been predicted by either of these theories. The discrepancies, moreover, are found to increase with rib flexibility. From author's summary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 4391, 4392, 4397, 4414, 4501, 4522, 4523, 4526, 4528, 4529, 4531, 4535, 4540, 4585)

4472. Jung, H., Theory of creep (in German), 9th Congrès intern., Mécan. appl., Univ. Bruxelles, 1957; **8**, 399–408.

This is a three-dimensional theory of metallic creep assuming proportionality between creep strain rate and stress deviation tensors. Such a theory, seemingly unknown to author, was first given long ago by reviewer [IV International Congress of Applied Mechanics, Cambridge 1934; Proceedings, 228–229, 1935]. In this paper the factor of proportionality (from considerations of theory of rate processes) is given as function of second stress deviation invariant and absolute temperature. Experiments with steels at 600–700C in uniaxial tension over periods of up to 5000 hr are said to support author's equation but contradict obviously known results for other metals reported by J. E. Dorn et al [AMR **8** (1955), Revs. 2728, 3058, 3060]. There are no references to the abundant literature on subject.

F. K. G. Odqvist, Sweden

4473. Patel, S. A., Venkatraman, B., and Hodge, P. G., Jr., Torsion of cylindrical and prismatic bars in the presence of steady creep, *J. appl. Mech.* **25**, 2, 214–218, June 1958.

Constant temperature and constant load conditions are discussed, attention being concentrated on secondary creep phase.

Assuming stress-strain creep relation $\dot{\epsilon} = (\sigma/\lambda)^n$, n odd, this is identified, following Hoff, with the nonlinear elastic relation $\epsilon = (\sigma/\lambda)^n$ with appropriate transferred boundary conditions. Following Prager, this is generalized three-dimensionally to $\epsilon_{ij} = C J_2^{m} s_{ij}$ so that a three-dimensional creep problem of above type can be treated as nonlinear elastic problem.

To solve such problems, energy expressions are set up which in turn lead to upper and lower bounds for actual (steady) stress distribution state.

To particularize foregoing to pure torsion, displacement components are chosen as functions of x, y, as for classical elasticity torsion. Substitution in energy expressions give bounds on torque for prescribed angle of twist. From these, bounds follow for angle of twist for prescribed torque.

Two particular torsion examples are treated, namely prisms of circular and polygonal cross section. For triangular cross-section angle of twist bounds differ by 30%. It is suggested, quite reasonably, that this is as close as is justified by present state of knowledge of metal creep behavior.

F. S. Shaw, Australia

4474. Ferrari, P., Influence of viscosity upon Risorgimento-type bridges with prestressed arch (in Italian), *G. Gen. civ.* **95,** 12, 1071-1092, Dec. 1957.

The theory for the calculations of deflections and stresses in the bridge described in the title is derived in detail. A numerical example is solved for various values of the viscosity coefficients.

From author's summary by B. A. Boley, USA

4475. Goldfein, S., Creep of glass-reinforced plastics, *ASTM Bull.* no. 225, 29-36, Oct. 1957.

An interim report on development of a method of determining the creep properties of glass-reinforced plastic laminates by short-time or static tests of their properties at temperatures up to 500F.

From author's summary

4476. Boller, K. H., Tensile stress-rupture and creep characteristics of two glass-fabric-base plastic laminates, *U. S. Dept. Agric., For. Prod. Lab. Rep.* 1863, 11 pp. + 5 tables + 24 figs., June 1957.

Stress-rupture and strain-time relationships were obtained from tests up to 1000 hours on two glass-fabric-base plastic laminates normally used in aircraft design. One was made with a typical polyester resin and 181 Volan A glass fabric, the other with a typical epoxy resin and 181 Volan A glass fabric. Data were obtained to show the effect of tensile loading at 0° to the warp direction under atmospheric conditions of 73F and 50% relative humidity and at 45° to the warp under the same atmospheric conditions and at 73 F in water. The data show that the stress-rupture curve may be approximated by straight lines on semi-logarithm coordinates, $\sigma_r = \sigma_0 - M \log t$, and that the strain-time relationship may be shown as a function of the applied stress and time. The strain ϵ_t at any time t may be expressed as $\epsilon_t = \epsilon' \sinh \sigma/\sigma_\epsilon + t^m m' \sinh \sigma/\sigma_m$. The constants were evaluated and are presented.

The data show that the stress-rupture characteristics of the material tested for this report at 0° to the warp are similar to that reported in *For. Prod. Lab. Rep.* 2039. The data here reported, however, show the lower stresses at which the material fails when loaded at 45° to the warp and show that the creep strains at 45° loading are up to 6 times greater than creep strains at 0° to loading.

From author's summary

4477. Rabotnov, G., Some problems of creep (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 288-292.

The behavior of some materials in the strain-hardening range is discussed. The strain-hardening is not isotropic. Example: The strain-hardening of a bar in tension has no influence to the consecutive stress-strain relation by torsion of the same bar. A known theory about the relations between tension, plastic deformation, velocity of deformation and temperature is verified by experiments with strips of steel-chrome-molybdenum in the range of 500C. The relation is stated and compared with the theory. The yielding in three dimensions is discussed with the assumption of the existence of a creep potential, which is a function of the stresses and the plastic deformations. The derivative of the potential to a stress component gives the corresponding plastic velocity component. A simplified example for this is given.

L. Foppl, Germany

4478. Kosla, G., and Findley, W. N., Prediction of creep from tension tests at constant strain rate (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 275-287.

Paper presents some results of continuing work by the senior author and his associates in the general field of stress-strain relationships, including creep, relaxation, and the search for mechanical equations of state. Reference is made to previous papers setting forth equations for creep and stress-strain; the results of tests on canvas-based laminates are used to compute the necessary constants for the equations; and the equations are used for prediction and to check experiment against prediction.

Discrepancies noted are ascribed to changes in the properties of the material over a ten-year period, and possible sources of error in the computations are noted.

The search for equations of state is a difficult but important one. This paper and associated papers by the authors represent one determined effort to find suitable equations of this type.

A. G. H. Dietz, USA

4479. Murthy, P. N., Theoretical investigation of creep and crack density studies in Stresscoat, *Proc. Soc. exp. Stress Anal.* **15,** 1, 57-64, 1957.

The viscoelastic behavior of Stresscoat is examined. Part I deals with the creep properties of Stresscoat. In Part II a simple analysis is made to arrive at a general semi-empirical formula to fit experimental (n, ϵ) curves and (n, b) curves (ϵ normal strain, n crack density, b thickness of coating).

From author's summary

4480. Rowe, J. P., and Freeman, J. W., Effect of overheating on creep-rupture, *NACA TN* 4224, 36 pp. + 7 tables + 21 figs., Mar. 1958.

The effects of overheats to temperatures of 1,650, 1,800, 1,900, and 2,000 F were evaluated in terms of the changes in creep-rupture properties at 1,500 F of M-252 alloy under stresses within the range of rupture strengths of the alloy for 80 to 1,000 hours. Overheat periods were predominantly of 2-minute duration and were applied cyclically at approximately 5- or 12-hour intervals. The results are compared with results of similar tests on S-816 and HS-31 alloys.

From authors' summary

4481. Tsaritsyn, V. V., Problem of the physical bases of rock destruction (in Russian), Trudĭ soveshch. po koordinatsii issled. v oblasti otdeleniya ot massiva uglei i porod. Moscow, Izd-vo *Akad. Nauk. SSSR,* 1954, 130-142; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2304.

A structural model is presented of an elastic-plastic body with variable elasticity and viscosity. The model represents in itself an articulated four-link assembly, in which one lateral link is elastic (a spring) and the other is plastic (a cataract). The point of application of force to the top link of the four-link assembly is capable of variation in the process of deformation. The deformation equation of this model has the form of

$$\frac{\sigma(1+\theta)}{\mu} = 2\frac{d\epsilon}{dt} - \frac{\theta}{E}\frac{d\sigma}{dt}$$

where σ is the stress, ϵ the relative deformation, E Young's modulus, t time, μ the viscosity coefficient, and θ the structural coefficient.

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4482. Gol'denblat, I. I., Some problems in the theory of elastic-plastic deformations (in Russian), Issledovanic prochnosti, plastichenosti i polzuchesti stroit. materialov, Moscow, 1955, 5-32; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 917.

Arising from the general tensor properties of the fields of deformation and stresses, and also from the circumstance of the existence of deformation potentials, equations are obtained for the theory of small elasto-plastic deformations of anisotropic media and equations for some variants of the theory of flow. For isotropic media, which remain isotropic even in the process of deformation, and when deformations are small, it is shown that the linkage between σ_{ik} and ϵ_{ik} becomes fully determined when two unvarying equations are fixed. Arising from only two conditions, that the spatial deformation shall be elastic and that there exists a deformation potential, a system of recording equations is deduced for the theory of small elasto-plastic deformations, significantly more convenient for use in transitions to the anisotropic media.

For linear-elastic media an analysis is carried out of the tensor of the moduli of elasticity. For anisotropic media, with the help of the tensor of anisotropy, several general relations are obtained, in particular an expression for the tensor of the moduli of elasticity of an anisotropic medium through the tensor of anisotropy, and it is shown that the tensor of the moduli of elasticity allows not only one but a series of equivalent presentations with the aid of the tensor of anisotropy. Further, an equation is deduced describing the elasto-plastic deformation of arbitrary anisotropic media and, in particular, of a medium possessing the symmetry of cubical crystals. This deduction is based on the assumptions that the first invariant of the stress tensor is dependent on the invariants of the tensor of anisotropy and that there exists a deformation potential when its form is differentiated for the process of loading and the process of unloading.

The theorem is demonstrated that if the components of a symmetrical tensor of the second degree b_{ik} appear as functions of the components of another symmetrical tensor a_{ik}, when by means of the functions an absolute resolution into a converging series is permissible, then these functions allow a compact presentation by means of the determined formulas. This presentation becomes completely determined if three invariant equations are assigned, linking six arbitrarily selected independent invariants of tensors a_{ik} and b_{ik}. The author, when examining the nonlinear elastic system under the effect n of generalized forces, puts forward the case that, side-by-side with the potential of energy and Castiliano's potential, there exists also potential $2^n - 2$, and that Castiliano's theorem appears to be a specific case in a much wider theorem.

A. K. Malmeister

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4483. Zaitsev, G. P., Basic formulas for calculations in the sphere of finite elastic-plastic deformations (in Russian), *Fiz. metallov i metallovedenie* **2**, 1, 120-124, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 916.

Formulas are deduced for angular deformations (slip) when there is present finite elastic-plastic deformation, finite elastic deformation, and finite plastic deformation. It is shown that the formulas, determining the relations of differences of the principle stresses to the differences of the corresponding principle elongations or angular deformations emerge in consequence of the application of the principle of superposition. As a specific case the calculation for the deformation of rubber is given. The basis for the initial formulas is not stated.

V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4484. Rozovskii, M. I., Some processes of deformation of materials (in Russian), *Izv. Akad. Nauk ArmSSR* **8**, 3, 33-40, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1290.

In view of the fact that Kelvin's simple model only illustrates the deformation of materials qualitatively, a mechanical model is examined, consisting of a statistical assembly of successively connected Kelvin models. In the result the process of a high elastic deformation is expressed as a time variable, with the period of an elastic after-effect $\theta = 1/f(t)$, where $f(t)$ is a function of time, the form of which is determined from the experiment. For polyisobutelene according to the data of Rebinder and Chumakov $f(t) = 0.08t^{-0.42}$. In a similar way author examines the relaxation of the stresses emanating from an assembly of Maxwell models connected in parallel. The drop of stress σ is expressed by the formula

$$\sigma = \sigma_0 \exp\left(-\int_0^t \varphi(t)dt\right)$$

where, as an issue of the data of Dogakdin, Bartener and Renzikovskii, $\varphi(t) = 0.07t^{0.72}$ for rubber. The relaxation and creep of metals were examined by the same method. It was shown that, by means of the assembly values of $\varphi(t)$ and $f(t)$, the known formulas of Oding and Smith can be obtained.

G. M. Bartenev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4485. Matschinski, M., Linearization of equations of plasticity (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8** 166-178.

A rational procedure for approximating the two-dimensional yield condition by a set of linear functions of stress is proposed. It is suggested that the method may be useful in cases of contained plastic deformation, i.e., where plastic regions exist but where the plastic-rigid material which would not deform. No examples are given.

P. G. Hodge, Jr., USA

4486. Lee, M.-H., Effect of stress-strain relations of material on solution of plane stress problems with large plastic deformation (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8**, 156-165.

Two-dimensional plasticity problem is discussed for strains including second-order terms. A strain-hardening deformation theory is considered. Author suggests that if boundary loads are maintained in proportion, loading will be almost proportional, and he uses this to simplify problem. Results of previous papers on plane stress with rotational symmetry are quoted in support of conjecture. Since one can easily construct truss or frame problems in which proportional boundary loading leads to the extreme case of stress reversals in the interior, reviewer believes that hypothesis must be carefully evaluated in relation to each particular application in more complex problems.

P. G. Hodge, Jr., USA

4487. Tupper, S. J., Some remarks on the conditions at the onset of plastic strain instability in metals (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8**, 145-155.

General strain-hardening deformation law of J_2-type is assumed. Instability strain under monotonically increasing load P and single strain component is defined as strain for which further strain is possible with no increase in load, i.e., $dP = 0$. Concept is generalized to bi- and tri-axial states. Applications are given to uni-axial tension, block under homogeneous tri-axial tension, and closed circular cylindrical shell under pressure and

tension. Results are valid for any stress-strain law of type considered, with particular reference to power law.

P. G. Hodge, Jr., USA

4488. Hodge, P. G., Jr., Piecewise linear plasticity (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8**, 65–72.

In condensed form author describes his theory, presented in full elsewhere [AMR **11** (1958), Rev. 2151]. As an example, a simply supported plate subjected to a uniform load is analyzed. Only results, no details, are given. A. Isaksson, Sweden

4489. Phillips, A., An experimental investigation on plastic stress-strain relations (in English), 9th Congrès intern. Mécan. Appliquée, Univ. Bruxelles, 1957; **8**, 23–33.

Paper describes experimental investigation of plastic deformation of commercial pure aluminum subjected to biaxial states of stress. Various loading paths were accomplished by combined tension and torsion of their tubes. Results indicate the direction of the plastic strain increment is approximately as predicted "by the simple incremental theory of plasticity" (normal to von Mises yield surface). Abrupt changes in direction of stress increments were accompanied by changes in direction of plastic strain increments. Author indicates the possible dependence of yield surface on path of loading. Small changes in direction of plastic strain increment during loading in fixed direction suggest obtuse corners in yield surface. Author notes small deviations in plastic strain increments due to creep. G. A. Wempner, USA

4490. Ol'shak, V., Plane problem of the theory of plastic flow of heterogenous bodies (in Russian), *Byn. Pol'skoi Akad. Nauk Otd.* (4), **3**, 3, 121–126, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 922.

A review of the author's previous works, permitting the extension of the theory of plasticity to heterogenous bodies. Basic equations are put forward for the plane problem. These equations find their application in the calculations for a thick-walled cylinder under the action of internal pressure. In cases of heterogenous materials of special types the transition of the cylinder to the plastic state may take place instantaneously.

M. Sh. Mikeladze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4491. Abbasov, A. A., and Mirzadzhanzade, A. Kh., Approximate solution of the problem of a nonstationary movement of a viscous-plastic medium in a round cylindrical tube (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekn. Nauk* no. 12, 122–124, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1976.

An estimate is made of the accuracy obtained by substituting the average sectional velocity for the actual velocity (a method proposed by the abstractor and S. M. Targo, *Dokladi Akad. Nauk SSSR*, **54**, no. 3, 1946) in the case of an irregular, rectilinear parallel stream of a viscous incompressible liquid in a cylindrical tube. By the very same method a solution is built up for the problem of an irregular flow of a viscous plastic medium in a cylindrical tube while taking into account the change of radius of the center (core) with time. The results of the numerical calculations are given in tabular form.

N. A. Slezkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4492. Sharapin, E. F., Resistance of metal to flow when pressed between flat surfaces (in Russian), *Trudi Kbar'kovsk. politekhn. in-ta* **5**, 101–111, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 919.

A review is given of the literature on the subject of the resistance of metal cylinders when pressed between plane-parallel faces. The author's attempts to show discrepancies in the works examined are not always well-founded. At the end of the article an approximate analysis is given of the stressed condition in the case of nonparallelism of the working surfaces of the deforming instrument.

G. A. Smirnov-Alyaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4493. Eason, G., The effect of work-hardening on the behaviour of circular plates under transverse concentrated load (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8**, 103–111.

Paper gives an elementary illustration of the use of Prager's work-hardening law, in conjunction with a piecewise linear yield condition, to obtain analytically simple solutions of certain plastic problems. Example is small bending of circular plate under central point force and either simply supported or clamped at the edge. Engineering significance of analysis is not assessed.

R. Hill, England

4494. Wood, W. A., and Segall, R. I., Softening of cold-worked metal by alternating strain, *J. Inst. Metals* **86**, 4 pp., 1957–1958.

Specimens of cold-worked metals (copper, nickel, aluminum) have been subjected to alternating-torsion tests, and measurements have been made of the proof stresses required to impose successive reversals of plastic strain. Further strain-hardening occurs as the first reversals are applied, but this hardening soon reaches a peak which is followed by softening. The latter is the more marked as the preliminary cold working is heavier and the plastic amplitude smaller. This observation of softening is taken to indicate that alternating strain tends to relax excessive internal stresses rather than to build them up in the manner suggested in various theories of fatigue. A mechanism is proposed whereby stress relaxation would occur at the surface of a specimen because the fine to-and-fro slip movements in alternating strain may build up slip bands with notch-like contours.

From authors' summary

Failure, Mechanics of Solid State

(See also Revs. 4515, 4522, 4526, 4533, 4534, 4536, 4548)

4495. Zawadzki, J., The reduced pressure as a strength parameter; the increase of the unit free energy as a measure of effective stress (in Polish), *Rozprawy Inż.* **5**, 3, 357–398, 1957.

Paper presents a strength theory based on the fundamental assumptions and principles of the theory of a solid body. This hypothesis belongs to the energy group and concerns only polycrystalline bodies, crystallizing in a regular system and subject to Hooke's law. It may also be used for plane or space-centric systems.

General theoretical problems necessary for the formulation of the theory are discussed and the equation of a solid body is analyzed. In the theory described, the energy of the elastic forces and the increase of the energy of atom vibration about the neutral position are assumed as a measure of effective stress. Two variants of the theory are elaborated concerning the case where energy of atom vibration is (1) a linear function, or (2) a quadratic function of the mean stress. The alternative (1) concerns bodies of small volume change for relatively high loads, while the alternative (2) concerns quasi-isotropic bodies, crystallizing in a regular system and subject to Hooke's law.

Z. Olesiak, Poland

4496. Winne, D. H., and Wundt, B. M., Application of the Griffith-Irwin theory of crack propagation to the bursting behavior of disks, including analytical and experimental studies, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-249, 23 pp.

Paper presents the results of bursting tests of large, bored and effectively notched disks removed from long rotor forgings. Most of the tests were conducted at room temperature. For the particular disk geometry employed, the net average tangential stress at bursting speed was as low as 25,000 psi for brittle-behaving materials and as high as 77,000 psi for materials approaching ductile behavior. These correspond to 26% and 92% of yield strength, respectively. The Griffith-Irwin theory of crack propagation is adapted to the calculation of G_c, fracture toughness, from notched-disk bursting-test results. It is shown that G_c from disk tests agrees with G_c obtained from slow notched-bend tests, and therefore appears to be a property of material, largely independent of specimen size. The actual magnitude of G_c permits the classification of forgings by the degree of their susceptibility to brittle fracture in the presence of discontinuities. G_c and the ratio K_{ys} of room temperature bursting strength to yield strength are found to correlate well with the material Charpy V-notch fracture appearance transition temperature. As the latter is reduced, G_c and K_{ys} are increased. From authors' summary

4497. Irwin, G. R., Analysis of stresses and strains near the end of a crack traversing a plate, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-22, 4 pp.

A substantial fraction of the mysteries associated with crack extension might be eliminated if the description of fracture experiments could include some reasonable estimate of the stress conditions near the leading edge of a crack, particularly at points of onset of rapid fracture and at points of fracture arrest. It is pointed out that, for somewhat brittle tensile fractures in situations such that a generalized plane-stress or a plane-strain analysis is appropriate, the influence of the test configuration, loads and crack length upon the stresses near an end of the crack may be expressed in terms of two parameters. One of these is an adjustable uniform stress parallel to the direction of a crack extension. It is shown that the other parameter, called the stress-intensity factor, is proportional to the square root of the force tending to cause crack extension. Both factors have a clear interpretation and field of usefulness in investigations of brittle-fracture mechanics. From author's summary

4498. LaRocca, E. W., Time-temperature relationships for rupture of metals in combustion atmospheres, *Jet Propulsion* **27**, 6, 674-675, June 1957.

4499. Irwin, G. R., Relation of stresses near a crack to the crack extension force (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8**, 245-251.

The Sneddon analysis of stresses and strains at a crack and the Griffith strain energy release theory are discussed. The work reported upon tends to show the relation between the Griffith strain energy release rate and the stress intensity at the leading edge of crack. It is pointed out that if the "fail safe" factor is to be estimated with respect to a fast running crack, one must know the critical force needed to start or stop a fracture. Tabulated are a series of crack extension forces. J. P. Vidosic, USA

4500. Murzewski, J., Statistical theory of a brittle quasi-homogeneous body (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5**, 313-320.

4501. Feld, J., Failures of concrete structures, *J. Amer. Concr. Inst.* **29**, 6, 449-470, Dec. 1957.

An historical survey of concrete failures of the last half century in the United States discusses significant examples without attempting to list all failures. Author touches on legal aspects from the Code of Hammurabi through English common law with some observations on present code requirements as they relate to different types of failure. Concrete failures are grouped according to their major causes: design deficiency, drafting and detailing errors, concrete mix, supervision omission, frost protection defects, bearing wall deficiency, foundation deficiency, faulty erection techniques, temperature and shrinkage, secondary stresses, and inadequate formwork. From author's summary

4502. Dekhtian, I. Ya., and Osipov, K. A., Failure of metals at elevated temperatures (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **104**, 2, 229-232, Sept. 1955.

4503. Mason, W. P., Internal friction and fatigue in metals at large strain amplitudes (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **5**, 379-390.

A barium titanate transducer coupled to an exponential "horn" can produce large strains in metals. By using a final horn with a necked down section, it is possible to concentrate the strains in a small specimen. Measurements of the impressed voltage and a voltage from a pick up electrode on the titanate make it possible to calibrate the device so that the internal friction, change in elastic constant, and the strain in the sample are all determined.

Measurements for a number of lead and aluminum samples show that the internal friction can be divided into three amplitude ranges. These can be correlated with dislocation processes occurring in metals and a connected picture is obtained for the causes of fatigue in metals. From author's summary

4504. Muttnyanszky, A., Designing for endurance under combined fatigue stresses (in Hungarian), *Jarmuvek mezogazdasagi gepek* **3**, 5, 136-142, May 1956.

In this significant and striking article, author gives a new method of designing applicable for every combination of steady and fluctuating loadings in case of bending and torsion. He eliminates the theories of failure under static stress, because these are not in accordance with recent combined stress fatigue experiments and he bases his method on fatigue tests exclusively.

As a first step, if static stresses superimposed on cycles of reversed stresses are combined, he introduces a σ_r bending mean stress and a τ_r torsional mean stress in a structure similar to the expressions of Mohr's theory and the Huber-Mises-theory. He assumes that these stresses substitute the combined static loadings, in view of fatigue. These are

$$\sigma_r = [\sigma^2 + a^2\tau^2]^{1/2} \quad \text{and} \quad \tau_r = [\sigma^2/a^2 + \tau^2]^{1/2},$$

a being the ratio of the yield point in bending and that in torsion.

The two mean stresses being known in case of bending or torsional fatigue stresses singly, he obtains the ranges of fluctuating bending and torsional stresses at the fatigue limits from the fatigue diagram by Haigh.

As a second step he constructs the ellipse quadrants of combined fatigue stresses which are introduced by Gough, Pollard and Clenshaw [*Aero. Res. Counc. Lond. Rep. Mem.* no. 2522, 1951] with greatest ease, and without particular tests, by the use of ingeniously arranged fatigue diagrams in bending and torsion.

For constructing quadrants the fatigue diagrams of Haigh are sufficient; moreover, author also shows these diagrams in a simplified form, where they can be constructed from the yield point and fatigue limit under reversed stresses only, belonging to different loading types.

Author states that his procedure concerning ductile steels is compatible with known experimental results and does not contradict them.

Paper discusses the determination of the numerous safety factors clearly and perspicuously.

In reviewer's opinion, author's ingenious and original method is an expressive new result of the designing for endurance. Its special significance is that the fatigue diagrams of Gaugh can be drawn well without particular tests. With the method, designing becomes simple and constructors in practice can, with little trouble, design for fatigue under combinations of fluctuating and steady stresses due to bending and torsion.

T. Gerey, Hungary

4505. Kemsley, D. S., The behaviour of cold-worked copper in fatigue, *Australia, Melbourne Aero. Res. Lab., Rep. Met.* 23, 12 pp. + 17 figs., July 1957.

Two batches of electropolished specimens, one in the cold-worked state (95 D.P.N.) and the other annealed (38 D.P.N.), were tested at ±16,000 psi (low stress) and ±25,000 psi (high stress) in a rotating-cantilever machine running at 6,000 cpm. At both stress levels, the average life of the cold-worked material was appreciably higher than that of annealed copper, although the hardness at fracture was approximately 75 D.P.N. in all cases. However at a given stress level the lives of cold-worked and of annealed copper were approximately equal from the point where the fracture hardness was first attained until fracture occurred. The difference in total life between the two groups of specimens is attributed to the relatively large number of cycles required to soften the cold-worked material, compared with the few cycles needed to harden the annealed specimens. Some confirmation of this suggestion was obtained from optical and electron microscopy, in that closely similar processes preceded failure in all cases. Recovery of cold-worked copper resulting from cyclic stressing also produced a sharpening of the diffuse X-ray diffraction rings, an increase in recrystallization temperature, and a lower rate of softening during annealing compared with the unfatigued material. The extent of this recovery under high stress conditions is equivalent to a reduction in tensile strain from 30% to 10%, but no direct comparison with tensile deformation is possible in the low-stress case. From author's summary

4506. Kelsey, S., and Spooner, J. B., Direct stress fatigue tests on Redux-bonded and riveted double strap joints in 10 S.W.G. aluminum alloy sheet, *Aero. Res. Counc. Lond. curr. Pap.* 353, 7 pp. + 4 tables + 28 figs., 1957.

Tensile fatigue tests were carried out on sheet specimens in D.T.D. 610B, 546B and 687A with double strap Redux and riveted joints. Bonded joints tended to fail by shear of the bond at the higher stress ranges and by tension of the sheet at the lower stress ranges. Riveted joints failed by tension across the first row of rivets in all cases, though tests on three-row riveted joints showed considerable improvement in endurance over those with two rows of rivets. Endurances were greater for bonded joints but with rather more scatter than for riveted joints, particularly where bond shear was the cause of failure.

From authors' summary

4507. Zhurkov, S. N., and Tomashevskii, E. E., Investigation of the durability of hard bodies. II, Dependence of long life on the stresses (in Russian), *Zh. tekh. fiz.* **25**, 1, 66–73, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1286.

An investigation is made, over a wider time range, of the earlier obtained data on time dependence of endurance. The widening of the range of measurements was carried out in the zone of rapid time-breaks (of the order of one hundredth and one thousandth part of a second). A quick method of stressing was adopted with the help of an electrodynamical instrument. The recording of the momentary forces acting on the sample was accomplished by an oscillograph method. To maintain the pressure σ constant when the measurements of the time "life" lie between 10 and 10^7 sec, a lever attachment was used, which automatically reduced the load proportionally to the alteration of the cross section of the sample. The change of time "life" τ, in very wide limits, embracing nearly ten orders of time for the materials examined (nitrocellulose, polymethylmethacrylate and cellulose diacetate, alumina and zinc) does not disclose divergence from the earlier established regularity $\tau = A\exp(-\alpha\sigma)$, where A and α are constants, determined by the properties of the material, the temperature, and the surrounding medium. G. M. Bartenev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4508. Williams, D., An experimental verification of the theoretical conclusions of R.A.E. Technical Note No. Structures 156 (*Aero. Res. Counc. Lond. curr. Pap.* no. 286): **"A constructional method for minimising the hazard of catastrophic failure in a pressure cabin," with further comments on its implications,** *Aero. Res. Counc. Lond. curr. Pap.* no. 357, 13 pp., 1957.

In a recent paper, author described a method of construction intended to make the shell of a pressure cabin immune from catastrophic failure at little or no cost in extra weight. The present note records the results of experiments carried out on a Comet I cabin that was modified to incorporate the new constructional method. These experiments, which include some very searching tests, amply confirm the benefits indicated by theory, and appear fully to vindicate the new method of construction.

The note also touches on the momentous implications that arise once this type of construction is accepted as meeting the claims made for it. From author's summary

4509. Kuhn, P., and Peters, R. W., Some aspects of fail-safe design of pressurized fuselages, *NACA TN* 4011, 7 pp. + 11 figs., June 1957.

4510. Burns, Anne, Fatigue loadings in flight-loads in the tailplane of a Comet 1, *Aero. Res. Counc. Lond., curr. Pap.* 363, 8 pp. + 4 tables + 9 figs., 1957.

Data are presented on the number of load cycles of various magnitudes occurring in the tailplane of a Comet 1A during normal ground and flight conditions. The conditions include flight in turbulence, take-off, landing, taxiing and ground running of the engine. The relative importance of the loads in the different conditions is illustrated by reference to the loads in a typical flight.

From author's summary

4511. Minami, Y., The effort of cathodic protection on the corrosion-fatigue of mild steel, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 69–70.

4512. Snyder, F. B., McNary, T. A., and Eberle, F., Investigation of suitability of 18-8 (Type 304) alloy for superheater service with respect to corrosion and stress-corrosion behavior in chloride-bearing steam condensate, ASME Ann. Meet., New York, N. Y., Dec. 1957, Pap. 57-A-174, 17 pp.

This is an investigation of the possibility of using nonstabilized 18Cr-8Ni-type alloys as high-temperature superheater materials in place of the present practice of using stabilized 18-8 materials. Comparative corrosion tests in synthetic steam condensates containing 38.4-ppm and 2000-ppm chloride have shown that the nonstabilized alloys, like the stabilized alloys, are not subject to intercrystalline corrosion attack in these media. Stress-corrosion tests in the same media showed that both stabilized and nonstabilized alloys suffered stress-corrosion cracking. No significant difference was observed in this respect between the two types of materials. In addition, nonstabilized 18-8 (Type 304) tubing, when installed in the pendant superheater of an operating

stationary boiler, showed no intercrystalline corrosion attack after up to 54 months of service. From authors' summary

4513. Meller, F., and Metzger, M., Some observations on stress-corrosion cracking of single crystals of AZ61X magnesium alloy, *NACA TN* 4019, 23 pp., July 1957.

4514. McHenry, H. T., and Probst, H. B., Effect of environments of sodium hydroxide, air, and argon on the stress-rupture properties of nickel at 1500° F, *NACA TN* 3987, 23 pp., Jan. 1958.

Stress-rupture lives of nickel tubes both containing sodium hydroxide and devoid of sodium hydroxide were determined for testing environments of argon and air. Sodium hydroxide had no effect on the strength of nickel in argon. Severe intergranular and surface oxidation of nickel tubes tested in air increased their rupture strength over that of similar specimens tested in argon. This strengthening was partly lost when the tubes contained sodium hydroxide. From authors' summary

Material Test Techniques

(See also Rev. 4467)

4515. Physics of non-destructive testing with particular reference to some of the new aspects, *Brit. J. appl. Phys.* Suppl. 6, iv + 72 pp., 1957.

Volume contains 13 papers of some 20 authors and the discussions presented at the Bristol Conference of 1956 of the nondestructive testing group of the Institute of Physics. Methods discussed in greater detail include optical and surface methods, various types of interferometry, optical shadow and total reflexion contact, x-ray diffraction, penetrant methods, optical fluorescence, and ultrasonic pulse methods. The applications discussed encompass testing of nonmetallic solids, medical diagnosis, detection of fatigue in metals, and testing of fibers and their molecular structure. The possible application of nuclear magnetic resonance is discussed. The general aspects of the magnetic properties and structure of metals, the effects of penetrating radiations and the structural changes during fatigue are considered. On the whole, the volume gives a very good cross section of the latest developments and trends in nondestructive testing.

D. Vasarhelyi, USA

4516. Dugdale, D. S., Vickers hardness and compressive strength, *J. Mech. Phys. Solids* **6,** 2, 85–91, 1958.

Hardness and compression tests are reported for a wide variety of materials. A simple empirical method for relating hardness number to the stress-strain curve is suggested. The correlation obtained leads to the conclusion that the Vickers test is not at all sensitive to yield stresses corresponding to compressive strains greater than 0.15. From author's summary

4517. Kosaka, Y., On the dynamic testing of mortar, *Technol. Rep. Osaka Univ.* **7,** 231/256, 95–100, Mar. 1957.

The relations between the physical quantities measured by dynamic testing and the statical strength of mortar specimens were investigated, as one of the fundamental experiments establishing the nondestructive method of concrete. From the test data, the standard deviations of strength around the regression line and the correlation coefficients of each relation are obtained, from which the accuracy for predicting the strength is judged. The results show that the most suitable physical quantity to predict the strength of mortar specimens without the knowledge of the age and the mixing ratio is dynamic Young's modulus.

From author's summary

4518. Vernon, E. V., An apparatus for the determination of dynamic elastic moduli at low strains, *J. sci. Instrum.* **35,** 1, 28–29, Jan. 1958.

An electronic apparatus is described for the determination by a resonance method of Young's modulus and the modulus of rigidity of materials in the form of cylindrical rods. Results can be obtained at strains as low as 10^{-9}. The method of calculation of the moduli from the observed resonant frequencies is given.

From author's summary

4519. Campbell, J. D., and Maiden, C. J., The effect of impact loading on the static yield strength of a medium-carbon steel, *J. Mech. Phys. Solids* **6,** 1, 52–62, 1957.

Experiments are described in which annealed medium-carbon steel specimens were subjected to rapidly applied compressive loads maintained for times of the order of 10^{-4} sec. The applied stresses were between two and three times the static upper yield stress of the steel, and the permanent deformation varied from 1.2% down to very small amounts.

Static stress-strain curves were obtained by reloading the specimens in compression immediately after impact. It appears that the upper yield stress can be considerably reduced by the application of an impact stress of insufficient magnitude and duration to cause appreciable permanent deformation. This reduction is related to the number of dislocations freed from their carbon atmospheres during the impact loading.

The reduction in the upper yield stress is found to be greatest after an impact causing about 1% permanent strain. Tests at a temperature of −84 C indicate that the effect of an impact depends mainly on the permanent strain caused, and not directly on the stress or duration of the load.

From authors' summary

4520. Gerard, G., and Papirno, R., The impact tube technique for dynamic stress-strain measurements (in English) 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 439–447.

The impact tube, as designed by the authors and described in an earlier paper, is used for the determination of dynamic stress-strain characteristics of materials in the shape of circular diaphragms. They are loaded from the elastic into the plastic range by means of a difference in the gas pressures on both sides of the diaphragms, which, being of a transient nature, makes it possible to obtain load cycles with durations in the millisecond range.

Some materials (annealed aluminum) did not show a marked difference in the yield strength under static and dynamic loading; mild steel, however, with stress rates of about 10^7 psi/sec exhibited an increase of the yield strength of 80%.

R. G. Boiten, Holland

4521. Belyaev, Yu. V., Estimating the extent of utilization of the impact energy in impact machines (in Russian), Issled. friktsionnykh par i udarnykh mashin, Moscow 1955, 35–50; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2448.

Machines are examined which have an impact action typical of pneumatic drills, in which the component, acting directly on the material being manipulated, obtains its energy from the impact on it of a special drill-center. An analysis is carried out of different ways for determining the k.p.d. (coefficient of useful action) of the impact mechanism of the machine; author comes to the conclusion that not one of the existing formulas appears to be sufficiently satisfactory. On the basis of the solution of the problem of the longitudinal impact of two elastic free rods of constant cross section, one of which up to the moment of impact is immovable while the other moves with a constant velocity along its length, formulae are obtained for the coefficient of transfer of kinetic energy when the impact is represented by η. The coefficient indicated is determined as the ratio of the kinetic energy of the first rod (the

drill-center) before impact to the kinetic energy of the second rod (the working component) after impact when the latter is moving with the velocity of the center of inertia, that is, when not taking into account the oscillation energy. In the case of rods with identical levels of cross section, $\eta y = l_1/l_2$ when $l_1 < l_2$ and $\eta = l_2/l_1$ when $l_1 > l_2$, where l_1 and l_2 are the lengths of the first and second rods; for unidentical cross sections of the bars a much more complex relation is indicated. The formulae obtained were checked experimentally, disclosing a satisfactory consonance with the calculated data for sufficiently long drill-centers ($l_1/d_1 > 2$, where d_1 is the diameter of the cross section of the drill center); significant divergence was obtained in the case where $l_1/d_1 = 1$.

I. I. Blekhman

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4522. Signorelli, R. A., Johnston, J. R., and Garrett, F. B., Effect of prior Air Force overtemperature operation on life of J47 buckets evaluated in a sea-level cyclic engine test, *NACA TN* 4263, 14 pp. + 3 tables + 11 figs., Apr. 1958

Buckets of S-816 alloy overtemperatured in service operation were evaluated in laboratory and engine tests. Some buckets were tested in the as-overtemperatured condition while others were heat-treated prior to testing. Results indicated that overtemperatured buckets did not fracture in abnormally short operating times, although life in stress-rupture tests was reduced. Cracks, particularly on the leading edge, developed after short operating times but did not propagate to fracture during several hundred hours of operation. From authors' summary

4523. Foster, E. L., and Heap, H., High-temperature tensometry and its application to amorphous polyethylene terephthalate, *Brit. J. appl. Phys.* **8,** 10, 400–402, Oct. 1957.

Amorphous polyethylene terephthalate will crystallize at elevated temperatures either by the action of the temperature alone or as a result of a stretching process. An apparatus has been constructed by means of which the stress-strain curves of amorphous polyethylene terephthalate in the rubber-like state may be investigated under conditions where the material is heated for a period of not more than one second before the application of the strain. In this way spontaneous crystallization is minimized and the crystallization due to stretching may be studied. The effects of both temperature and straining rate on the shape of the stress-strain curve have been investigated and the results indicate that the crystallization is stress-controlled. The application of the results to the fiber spinning and drawing processes is discussed.

From authors' summary

4524. Johnson, D. F., Investigation of some mechanical properties of thermenol compressor blades, *NACA TN* 4097, 8 pp. + 6 figs., Oct. 1957.

A series of tests was made comparing the mechanical properties of similar compressor blades of AISI-type 403 stainless steel and thermenol. Eighth-stage J47 and J65 compressor blades of each material were tested. Modulus of elasticity, modulus of rigidity, and damping were slightly lower for thermenol. However, thermenol showed better resistance to corrosion by sea water, and the thermenol blades proved equal or superior to the stainless-steel blades in fatigue strength.

From author's summary

4525. Bradfield, G., and Levi, F. A., Measurement of elasticity and anelasticity of small disks by an inductor method, *Brit. J. appl. Phys.* **9,** 1, 13–16, Jan. 1958.

An instrument is described operating on the inductor principle to set a small disk into radial vibration so that one of its elastic constants can be determined from its frequencies of resonance. The method of testing also permits the internal friction to be measured as the ratio Q_m of the real to the imaginary component of the elastic compliance. The accuracy of determination of the resonance frequency is to better than 1 part in 50,000 and the determination of the internal friction ratio to better than 1 part in 50 in a typical case when, for example, the above ratio Q_m is about 3000. The elastic constant directly derived is the "sheet" modulus $E/(1-\sigma^2)$ where σ is Poisson's ration and E is Young's modulus. From authors' summary

Mechanical Properties of Specific Materials

(See also Revs. 4475, 4476, 4478, 4489, 4498, 4500, 4503, 4511, 4512, 4515, 4516, 4517, 4519, 4524, 4546, 4551, 4755)

Book—4526. Institution of Metallurgists, Behaviour of metals at elevated temperatures, New York, N. Y., Philosophical Library, 1957, vii + 122 pp. $6.

This book consists of the full text with illustrations of four lectures on metals at high temperatures which were delivered in 1956 at a Metallurgists Refresher Course of the British Institute of Metallurgists. The subject matter is treated in a phenomenological manner with practically negligible effort to organize the material to show the similarities so desirable for mnemonics. Within the limits of available space, the treatment is extensive and clearly presented in an authoritative manner. The first paper, on the "Engineering properties of metals at high temperatures," considers six properties: stability of physical properties and dimensions, elastic constants and coefficient of expansion, resistance to plastic deformation and fracture under constant and complex stresses, behavior under fluctuating stresses, behavior under fluctuating temperature, resistance to chemical attack as well as stress corrosion. The second paper considers the "Effect on metals of temperatures up to 450° C" from the viewpoint of airframe structures and the materials of interest for this use. The third paper, on "Non-ferrous high-temperature materials," presents an excellent review of the available materials, coatings, and other pertinent information. Nonferrous is roughly defined as alloys or sintered compacts with less than 50% iron, but the separation is arbitrary and freely overlooked to present the properties of a series of iron-containing materials. The fourth and final paper is on high-temperature steels which are grouped, for discussion, under carbon steels, low-alloy steels, intermediate-alloy steels, 12 per cent chromium-type steels and austenitic steels. The latter two papers are particularly well balanced in covering the entire subject, although still from the phenomenological viewpoint!

F. Todd, USA

4527. Kenneford, A. S., and Williams, T., Effect of heating and cooling on the mechanical properties of an alloy steel, Instn. Mech. Engr. Lond., Prepr. 8 pp.

An investigation has been made of the effect of heating to, and cooling from, a temperature above the critical range on the mechanical properties of an alloy steel to specification B.S. En 29.

It has been shown that, on rapid cooling from a temperature above the critical range, the steel possessed poor mechanical properties (low yield and tensile strengths) at all temperatures down to the commencement of martensite formation at about 300 C (572 F). Below this temperature there was a sudden increase in yield and tensile strengths, accompanied by a marked decrease in ductility.

The relation between these mechanical properties and the incidence of cracking after repeated heating and rapid cooling is briefly discussed. From authors' summary

4528. Stepnov, M. N., Mechanical properties of magnesium alloys at high temperatures (in Russian), *Trudi Mosk. aviats. teknol. in-ta* no. 25, 103–111, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1318.

By means of tensile tests approximate diagrams of the true stresses were obtained, and other mechanical properties in the plastic zone of magnesium alloys of types MA1 and MA8. The tests were carried out at temperatures of 20 to 400° on flat test pieces cut off from sheets 2 mm thick along and across the direction of rolling. When comparing the mechanical characteristics of such test pieces a marked anisotropy appeared in the properties of alloy MA8, which maintains a stable character up to 250–300° and practically disappears only when the material is heated to 400°. The endurance properties in the longitudinal direction were 10–15% higher than the corresponding properties in the transverse direction; the plasticity, on the contrary, in the transverse direction was 10–15% higher than in the longitudinal. In alloy MA1 a difference was only observed in the plasticity at that period of time when the endurance properties were practically independent of direction. With increase of temperature in the test, a fall was observed in the endurance, the coefficient of hardening and the regular transverse constriction; in the longitudinal constriction and elongation up to rupture point, a rise took place.

M. P. Morkobets

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4529. Rovinskii, B. M., and Lyuttsau, V. G., Structural changes in aluminum when stresses are relaxed (in Russian), *Izv. Akad. Nauk. SSSR, Otd. tekh. Nauk.* no. 11, 1618–1621, 1953; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1321.

In order to explain the mechanism of relaxation in metals, a special method was used which included in the determinations the quality of interference spots on x-ray photographs of the test pieces, exposed to prolonged tension with a set value for the general deformation. The tests were carried out with test pieces of pure aluminum with an initial grain size of 0.03–0.04 mm. The method was described for taking x-ray photographs of a loaded test piece, taken frequently over a period of 500 hours. The quality of the interference spots deteriorates when a load is applied to the test pieces in an elastic zone (up to 15–20%) and gradually re-establishes itself up to the initial figure when stress relaxation sets in. Radiograms are shown, illustrating the appearance and disappearance of the spots. S. T. Konobeevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4530. Bollenrath, F., Sintered aluminium S. A. P., AGARD Rep. 103, 7 pp. + 3 tables + 16 figs., Apr. 1957.

From author's summary

4531. Narayanamurti, D., Gupta, R. C., and Narayanamurti, V., Influence of loading on the rigidity modulus and plastic flow of wood, *Appl. sci. Res.* (A) **7**, 2/3, 145–148, 1958.

4532. Osherovich, L. I., Experiments on wood for tension transverse to the fibre (across the grain), *Zavod. Lab.* **21**, 11, 1374–1377, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2535.

Results are described of an experimental investigation of a new type of test sample for testing wood for tension across the grain. The standard sample (according to GOST 6336–52) is distinguished by the presence of stress concentration and, as the result of this, a lowered value for the limit of endurance. Tests of the new sample, having a working part 40 mm long and of constant cross section 10 × 30 mm, with cross-over recesses toward the end widened parts, inserted in the clamps of the machine, showed a higher limit of endurance, 35–50 kg/cm² (instead of 20–25 kg/cm² of the sample according to the GOST 6336–52 standard), which approximates more closely the actual value of the resistance of the wood to tension across the grain. Using the same sample it is possible also to determine the modulus of elasticity. Values are given for the correction coefficients for moisture content for the limit of endurance and for the modulus of elasticity in the radial and tangential directions. Ya. M. Ivanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4533. Patrikeev, A. V., and Chibrikin, M. V., Problem of fatigue investigations of wood (in Russian), Vopr. drivesinovedeniya, Moscow-Leningrad, Goslebumizdat, 1953, 64–71; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2532.

A system for testing wood for fatigue endurance is put forward (shape of samples and method of clamping them, the number of loading cycles in 1 min, the maximum number of cycles, scheme for the testing machine for fatigue, etc.). The limits of endurance of the wood of pine and beech, obtained during the tests, comprise 22–25% of the limit of strength during static deflection in the tangential direction. A. F. Razhnystovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4534. Ashkenazi, E. K., An experiment to apply the first classical hypothesis to the evaluation of the endurance of wood under complex stressed conditions (in Russian), Tekhn. inform. po resul'tatam nauch.-issled. rabot Leningr. Lesotekhn. Akad. no. 15, 27–32, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1356.

An attempt is described to evaluate the strength of wood, viewed as an orthotropic material in a plane stressed condition, on the hypothesis of the endurance of the largest principal normal stresses by means of the superposition of the polar diagram of normal stresses on the different planes with the polar diagram of the limits of endurance of the wood in the principal planes of symmetry of its structure. The latter may be built either on the experimental data or on the theoretical equation of the limits of endurance, structurally analogous to the equation for the change in value of the modulus of elasticity of an orthotropic material in different directions in relation to the principal directions of elastic symmetry; the basis for the applicability of this equation for the evaluation of the resistance of the wood to the action of normal stresses is put forward in the work of the same author [ibid, no. 6]. Comparison of both curves for the case of axial compression along the fibers explains the formation of a slanting fold of disintegration. Some ideas are advanced for the application of the described method for calculating the strength of wood when in a general (3-dimensional) state of stress. S. A. Sementsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4535. Vasil'ev, P. I., Utilization of the conventional theories for describing the principles of the deformation of cement (in Russian), *Izv. Vses. n.-i in-ta gidrotekhn.* **53**, 292–295, 1955; *Rev. Zh. Mekh.* no. 2, 1957, Rev. 2231.

Author shows that the nonlinear theory of creep put forward by Yu. B. Rabotnova [*Vest. Mosk. un-ta*, no. 10, 1948] for use with metals, applicable for cement, does not agree with the experimental data, and that for cement it is expedient to apply the hereditary theory for the aging of cement proposed by N. Kh. Arutyunyan ["Some questions on the theory of creep,"—Gostekhizdat, 1952]. Further, author shows that Arutyunyan's formula, when there is a variable modulus of instantaneous deformation

$$\epsilon(t) = \frac{\sigma(t)}{E(t)} - \int_0^t \sigma(\tau) \frac{\partial}{\partial \tau} \left[\frac{1}{E(\tau)}\right] d\tau - \int_0^t f[\sigma(\tau)] \frac{\partial C(t,\tau)}{\partial \tau} d\tau$$

has to be defined more accurately in the following sense: in place of $f[\sigma(t)]$, $f[\sigma(t)/R(t)]$ should be taken where $R(t)$ is an intermittent resistance. M. M. Manukyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4536. Vasil'kov, A. N., Endurance of materials in conditions of a complex stressed state (in Russian), *Nauch. tr. kazansk. in-ta inzh.-stroit. neft. prom.-str.* no. 3, 73–108, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1339.

The problem is gone into of the endurance of cements, stone and other materials when in a complex stressed condition. The author, with the aid of some mechanical interpretations, obtains formulas for the determination of the mechanical characteristics of breakdown without making use of the experimental results, which are essential for the construction of the limiting curves of Mohr. This work is based on the hypothesis that at the moment of breakdown the surface of the crack is acted upon not only by a compression force (as is assumed in the Mohr theory) but also by a tension force. Formulas are deduced for the determination of the angles of slope of the surface breakdown, and also for the values of the shear and normal stresses. The problem is analyzed of the influence of the mean normal stress on the endurance and alteration of Poisson's ratio. The results of the calculations are compared with the experimental data. M. A. Zadoyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4537. Bjorklund, K., Determination of tensile strength of ceramic bodies (in Swedish), *Trans. Chalmers Univ. Technol.* no. 193, 78 pp., 1958.

4538. Bateson, S., Critical study of the optical and mechanical properties of glass fibers, *J. appl. Phys.* **29,** 1, 13–21, Jan. 1958.

The cooling rate for fine glass fibers in the 6–16 μ diameter range has been calculated by means of a new cooling equation. Typical strength-versus-diameter data are compared with the ratio of quenching time to the Maxwell relaxation, t_s/τ. Strength increases rapidly for $t_s/\tau \leqslant 1.0$ and τ is most probably of the order 10^{-4} sec at 1100 C. The refractive index decreases slightly in the critical region but the change does not indicate a significant rise in the fictive with increased quenching. For this reason structural changes are considered of secondary importance as a factor contributing to high strength. New strength measurements of glass fibers fit a distribution law with reasonable accuracy. It is therefore concluded that the flaw theory of high strength is valid. The influence of "hydrostatic" cooling upon flaw generation is discussed. From author's summary

4539. Thorkildsen, R. L., Tensile behavior of reinforced plastic laminations and composite plates, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-208, 27 pp.

From classical elastic theory author derives stress-strain relations for an orthotropic plate, e.g. rolled metal sheet, reinforced plastic sheet, or plywood, subjected to arbitrary plane stress. Results are presented in 30 graphs, very useful to designers, showing effective Young's modulus, Poisson's ratio, and shear modulus as function of orientation of applied stresses. Theory is extended to composite plates where the natural axes of the laminations may or may not coincide. A worked example shows the use of the graphs to calculate the elastic behavior of a composite plate, given the elastic constants of its components. R. L. Woolley, Iraq

4540. Coleman, B. D., Knox, A. G., and McDevit, W. F., The effect of temperature on the rate of creep failure for 66 nylon, *Text. Res. J.* **28,** 5, 393–399, May 1958.

Measurements have been made of the lifetime under dead load behavior of high tenacity bright nylon yarn in dry nitrogen at eight temperatures in the range 30–125° C. The data obtained have been interpreted using a previously published absolute reaction rate theory of the creep failure of oriented crystalline polymeric fibers. The prediction of the theory that the logarithm of the lifetime should be a linear function of the sustained dead load was found to be consistent with the experimental results at all temperatures investigated. The data were used to calculate estimates at each temperature for the displacement volume δ^* and the free energy of activation $\Delta F^\dagger$ for the breakdown process. An examination of the temperature dependence of $\Delta F^\dagger$ has yielded the conclusion that the negentropy of activation $-\Delta S^\dagger$ makes a negligible contribution to $\Delta F^\dagger$. The best estimate for the heat of activation for breakdown $\Delta H^\dagger$ was found to be ~ 49 kcal.

From authors' summary

4541. Scott, D. D., Selection and application of epoxy foams, *Mach. Design* **30,** 12, 127–129, June 12, 1958.

4542. Kuvshinskii, E. V., and Sidorovich, E. A., The effect of vulcanization on the dynamic elastic properties of rubber (in Russian), *Soviet Phys. (JTP)* **2,** 4, 632–636, Feb. 1958. [Trans. from *Zh. tekh. Fiz., Akad Nauk SSSR* **27,** 4, 702–706, Apr. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Plasticity, Forming and Cutting

(See also Rev. 4354)

4543. Johnson, W., The cutting of round wire with knife-edge and flat-edge tools, *Appl. sci. Res. (A)* **7,** 1, 65–88, 1958.

Experiments are described on the indenting and cutting of round wires between 0.063-in. and 0.625-in. diam of copper, galvanized and straight drawn medium carbon steel, and a special steel with wedge-shaped tools, to investigate the basic mechanics of the operation. Considerable use is made of some theoretically well-analyzed and analogous cases in the plane-strain cutting of strip, and experimental evidence of qualitative agreement is presented. The investigation was carried out to determine the effect on the greatest load required to sever material, of wedge tool angle, of a flat on the end of the wedge, wire diameter and material properties; in particular the logarithm of the greatest cutting load is shown to be directly proportional to the logarithm of the wire diameter. The paper concludes with observations on the physical action and consequences of cutting.

From author's summary

4544. Lindstrand, E., Wire drawings—a literature survey (in Swedish), *Jernkontorets Ann.* **142,** 3, 105–127, 1958.

4545. Shevtchenko, K. N., Theory of flow of metal as applied to the problem of rolling of wide and narrow strip (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 263–274.

Expressions are derived for the stresses and displacements in wide and narrow strips made of non-work-hardening materials and rolled without tension. The space between rolls is assumed to be small enough so that a mean value can be assumed for the stress along the height of the strip. The shear stress at the roll-strip interface is prescribed by friction laws which are written in terms of the normal pressure and relative velocity.

B. W. Shaffer, USA

4546. Vomik, A. I., Analysis of the flow process of molten metal in molds for pressure casting (casting under pressure) (in Russian), Lit'e pod davleniem, Moscow, Mashgiz, 1955, 14–30; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 455.

It is noted that the basic influence in the process of molten metal casting is the thermal regime, which should be investigated together with the flow process under pressure from the piston. As the result of some assumptions, author deduces a formula for the hydraulic and thermotechnical calculation of the process of casting.

In doing so it is shown that the hydraulic formulas are obtained to cover the case of steady flow, which is only possible in face of significant friction. In the opposite case the forces of inertia acquire important significance. It is also noted that as regards the practical requirements for accuracy the calculations by means of these formulas may be taken as fully sufficient. In conclusion it is stated that the hydraulic resistance of the machine assembly is no less significant than the mould resistance, but that the scheme of making the calculations does not differ in principle from the scheme affecting the mould, and in consequence is not dealt with in the present article. A. N. Klimentov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4547. Hayes, M. V., The use of numerically controlled machine tools, ASME Fall Meet., Hartford, Conn., Sept. 1957, Pap. 57-F-14, 5 pp.

4548. Colding, B., Testing of machinability by radioactive methods (in English), *Acta Polyt.* no. 243, (Mechanical Engineering Series no. 1), 32 pp. + 14 tables + 40 figs., 1958.

A large number of machinability tests were carried out on five different work materials, using radioactive carbide cutting tools. The tests were made in an ordinary lathe, provided with radiation shield. The wear on the carbide tools was determined by measurement of the radioactivity of the chips cut.

With one of the methods, the β-method, the β-radiation from small quantities of chips of the order of 1 g per measurement sample is measured by GM-tubes of the end-window type. The β-method enables separate measurement to be made of the wear on the clearance and the rake side of the tool.

The other method, the γ-method, measures the total activity from both sides of the chips by means of a thick-walled GM-tube, placed longitudinally in a double cylinder holding approximately 250 g chips.

Only the radiation from the isotope W187 (half-life 24.1 h) was employed, produced by neutron irradiation in a reactor generally with $10\text{-}20 \cdot 10^{11}$ n/cm^2·s for 1 hour, making the specific activity 25-50 mC/g.

The rate of wear was approximately constant up to the wearing out of the tool, after a rather brief period of running-in had gone, so that the mean activity in the chips produced during a few minutes' turning constitutes a relative measurement of the rate of wear. By means of reference measurements on a carbide chip dissolved in $NaNO_3$ and the cutting data used, absolute values of the tool-lives were obtained.

These two radioactive methods give approximately the same degree of accuracy, i.e. varying between ±2% and ±20% for about 10 measurements. The dispersion of the tool-lives was smaller with the radioactive methods than with the conventional tool wear method in some cases, while of the same order of magnitude in the remaining cases.

The total cost of test for a tool-life curve using the radioactive method is appreciably lower than the corresponding cost with the conventional method. From author's summary

4549. Drummond, W. E., Comments on the cutting of metal plates with high explosive charges, *J. appl. Mech.* **25,** 2, 184–188, June 1958.

4550. Herzog, J., and Weske, J. R., Characteristics of the technique of aerodynamic investigation by means of series of electric sparks, Inst. Fluid Dynam. appl. Math., Univ. Maryland TN 57-359, 16 pp. + 33 figs. + 25 appendices, July 1957.

4551. Marcu, V., Zelingher, N., and Freund, P., Investigations on metal spraying process (in Russian), *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2,** 1, 1957.

Authors discuss the metal spraying process, the characteristics of metallic particles, and the properties of sprayed metal coatings in comparison with the characteristics of a porous iron-coal alloy obtained by powder metallurgy. The particle size of this alloy is smaller, whereas the hardness of sprayed metal coatings is about three times greater than that of the porous alloy; consequently these coatings are better wear-resisting surfaces. Fatigue tests indicate that sprayed steel shafts are of satisfactory resistance. Finally, paper presents successful results obtained in repairing engine crankshafts and tram axles.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4552. Rice, J. L., Ruddle, R. W., and Russell, P. A., Recent developments in the manufacture of castings, Instn. Mech. Engr. Lond., Prepr. 21 pp.

Developments which have taken place in the last decade in foundry practice and in the alloys used to make castings are described. The main emphasis is on the effect of these developments on the soundness, mechanical properties, dimensional accuracy, and the cost of the finished casting, and less on the way the improvements have been brought about.

The topics discussed are: (1) the development of new and established processes; (2) alloy development; (3) inspection; (4) future trends.

The paper is confined to cast-iron and nonferrous alloys; advances in the production of steel castings are not covered. Many of the techniques referred to, though, are of general applicability.

From authors' summary

Hydraulics; Cavitation; Transport

(See also Revs. 4586, 4594, 4652, 4654, 4695, 4697, 4720, 4797, 4800)

Book—4553. Solomentsev, N. A., Hydrometry [Gidrometriia], 2nd ed., Moscow, Gidrometeoizdat., 1957, 459 pp. $1.50.

This is a second, slightly improved edition of a textbook for technical high schools. It contains: water stage observations, depth sounding, velocity measurement, determination of water discharge, construction of discharge curves, solid runoff and silt, some special measurements. Short literature list of 48 titles, exclusively Russian, is given. Foreign names are eliminated, only Stout is mentioned. S. Kolupaila, USA

Book—4554. Jevdjevic, V., Hydrology, Part I (Hidrologija) Belgrade, Hydrotechnical Institute J. Cerni, 1956, 404 pp.

This first volume contains water balance, mathematical methods in hydrology, precipitation, evaporation, infiltration, runoff, floods. Volume II will include hydrography, silt, ice, underground water, forecasting and other applications; volume III, hydrometry. Author of the first textbook in Serbo-Croatian language has successfully and logically adopted several new terms in this field. Diagram of stage fluctuations is called nivogram; of discharge variations-hidrogram, more correct than our hydrograph, which means rather an instrument. Particularly well elaborated is the mathematical part. Very interesting is the analysis of instability of the coefficients of variation and of asymmetry with extension of the time.

Several of the author's own methods are included, such as extrapolation of the discharge curve using probability diagrams for both stages and discharges. Works of European, American and Russian authors are used in this book; examples are taken mostly from the author's hydrologic investigations in Yugoslavia. The book is of great interest for multilingual hydrologists.

S. Kolupaila, USA

4555. Parde, M., Extraordinary floods of 1955 in the USA (in German), *Erde, Berlin* **89,** 2, 81–122, 1958.

Author, the great authority in hydrology of floods, analyzes the effect of tropical cyclones Connie and Diana and compares them with several previous ones, and especially the exorbitant flood in Central and North California in December 1955. Author praises the efficiency of American public organizations, which were able to publish the report on hydrology of the great disaster in one month.

S. Kolupaila, USA

4556. Parde, M., Catastrophic flows in function of basin areas (in German), Mitteilungen der Geographischen Gesellschaft, Vienna, **99,** 1, 1–34, 1957.

Known French hydrologist assumes a rough approximation of the maximum flood flow as a function of a square root of the basin area and investigates a variable factor. Author calls it regional coefficient, although it has a dimension. For majority of European rivers author determined this factor (in metric units) between 10 and 50; however, many floods were exorbitant and unbelievable, therefore conclusions are not particularly favorable for such a simplification.

S. Kolupaila, USA

Book—4557. Bogoliubova, I. V., Mud torrents (Selevyie potoki) and their expansion on the USSR territory (in Russian), Leningrad, Gidrometeoizdat, 1957, 152 pp.

Author presents a systematic study of history of torrents investigations. Disastrous mud torrents ("seli"), conditions of their formation, hydraulic elements of torrents, their expansion and possible progress of soil erosion are discussed. Bibliography contains 136 carefully selected titles, 134 of them Russian, 1 German and 1 French. Book is important for soil erosion control.

S. Kolupaila, USA

4558. Jaeger, C., The double surge-tank system (in French), *Houille blanche* **12,** 4, 481–495, Sept. 1957.

Stability of regulation in a power plant with a surge tank upstream of the turbines and another downstream is studied. Stability problem depends on ten independent variables, but author is able to reduce these to only four by means of an ingenious artifice, consisting of using as reference quantities the Thoma sections instead of the effective sections. Discussion is summarized in graphics giving, for different practical situations, the boundary curves of stability; from here the increase can be calculated which must be given to Thoma's sections in order to assure stability. Lastly, safety margins are determined, necessitated by reason of all circumstances neglected in the analytical study (losses of head in the forced pipe and variableness of efficiencies) and in order to assure sufficient damping.

D. Citrini, Italy

4559. Escande, L., Calculations for spilling surge tanks with incoming flow (in French), *Houille blanche* **12,** 4, 555–569, Sept. 1957.

Pursuing his detailed analysis on surge tanks, which has appeared in numerous papers, author determines analytically the volume spilling over the sill of a surge tank with incoming flow; calculations are conducted both on the hypothesis that incoming flow falls directly into the tank or enters the same below a restricted orifice. Integration of the equations can be reached if some simplifying assumptions are made about the law of flow over the sill. For some numerical cases results obtained are compared with those supplied by graphical (rigorous) method; the attainable approximation can be very good.

D. Citrini, Italy

4560. Hayashi, T., The governing equations for surging at the surge chamber of the tail-race tunnel due to load decrease (in Japanese), *Japan Soc. civ. Engrs. Trans.* no. 56, 1–11, May 1958.

In the course of down surging at the surge chamber of the initially full-flowing tail-race tunnel, the entrance of the free surface into the tunnel makes it impossible for the conventional surging equations for the pressure conduit to govern the surging at the surge chamber of the tail-race tunnel. New governing equations for this case are developed for practical design purposes by modifying the conventional surging equations for the pressure conduit. Special emphasis is laid on the maximum rise of the water level in the surge chamber in consequence of the counterflow in the tunnel subsequent to the down surging at load rejection, since the maximum rise is an inevitable top surge. Surging waves are derived by numerical integration of the new equations and compare satisfactorily with those given by experiment, through which validity of the new governing equations is affirmed.

From author's summary

4561. Shashkov, N. I., Field investigations of erosion in a river bed in the lower water of a dam (in Russian), *Trudi in-ta sooruzh.* AN. *UzSSR* no. 7, 137–160, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 518.

4562. Simonov, V. M., and Kushnareva, I. P., Influence of the angle of intersection of a water flow when passing over to discharge distribution between two bridge pier openings (in Russian), *Sb. stud. nauch. rabot. Saratovsk. avtomob.-dor. in-ta* no. 2, 15–27, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 528.

4563. Andreevskaya, A. V., The bottom and surface regions of "lower water" installations when there is flow over the ledge (in Russian), *Nauch. zap. Mosk. in-ta inzh. vod. kh. va* **18,** 69–83, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1903.

The problem is investigated of the lower boundary of the formation of the unflooded jump in the conditions of a plane problem; formulae are brought forward by A. A. Sabaneev [*Tr. Mosk. in-ta inzh. zh.-d. transp.* no. 11, 1929], by I. I. Levi [*Gidrotekhn. str-vo* no. 2, 1933], and by Einwachter [J. Einwachter, "Wehre und Sohlenabsturze," 1930]. The experimental data of the author are given, on the basis of which it is established that in the majority of cases the surface regime sets in owing to pressures below the stream, somewhat smaller than the hydrostatic pressure. As the result of the experiments, empirical relations are presented for the establishment of the depth of the "lower water" h_1 at which the surface regime sets in. Comparison of the results obtained brings the author to the conclusion that the formula of Sabaneev and I. I. Levi gives a margin in the determination of h_1; the formula of Einwachter commands greater accuracy, but it cannot be used as it contains some unknown quantity; the formula of the author gives good agreement with the observations.

I. I. Levi

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4564. Bashkirova, L. A., Tables for the hydraulic analysis of channels (in Russian), *Trudi Kuybysbevsk. inzh.-stroit. in-ta* no. 3, 113–118, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev: 3057.

To determine the depth h and bottom width b of trapezoidal channels the following expressions are proposed:

$$\frac{K_n}{b^{2.7}} = \phi\left(\frac{h}{b}\right) \qquad \frac{b^{2.7}}{K_n} = \phi'\left(\frac{h}{b}\right)$$

Author tabulates the values of the functions ϕ and ϕ' for different values of the ratio b/b and the coefficient of slope m.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4565. Kumin, D. I., Preobrazhenskii, N. A., and Yuditskii, G. A., Pulsation of a hydrodynamic load on the section of the pressure gallery beyond the sluice (in Russian), *Izv. Vses. n.-i in-ta gidrotekhn.* **54**, 78–85, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 482.

In contrast to the study of pulsation pressure at a given point an examination was carried out of the pulsation pressure on an isolated area of the wall. Investigations were carried out on a model of a water-carrying gallery of a marine sluice. For the measurement of the pressure on the part of the wall of the gallery, the construction of the model offered some freedom of vertical and horizontal movement. The tests showed the proportionality of the maximum pulsation pressures to the square of the discharge.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4566. Supolkin, G. A., Problem of hydraulic calculations for channels with a given rate of flow (in Russian), *Izv. Akad. Nauk Tadzh. SSR, Otd.estestv. Nauk* no. 12, 59–67, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 505.

The proposition is to evaluate channels of trapezoidal section at a given discharge Q, slope i, and velocity v, having preliminarily checked the possibility of the calculation, namely,

$$v_{\text{optimum hydraulic section}} > v_{\text{given}}$$

The velocity of the hydraulically optimum section $v_{o.h.s.}$ is obtained at the same time by means of the formula

$$v_{o.h.s.} = \frac{0.707\sqrt{i}}{n}\sqrt[4]{\frac{nQ}{\sqrt{i}\,(2\sqrt{1+m^2}-m)}}$$

Here m and n are the coefficient of side slope of the channel and the coefficient of roughness, respectively. If the specified condition is studied, then the determination of the depth of the channel h and the bottom width b is carried out in the following order. The function

$$\phi(\beta) = \frac{v}{Q}\left(\frac{nv}{\sqrt{i}}\right)^3$$

is first of all calculated and then the value of β from the formula

$$\phi(\beta) = \frac{\beta + m}{(\beta + 2\sqrt{1+m^2})^2}$$

To make calculation easier a table is given of the value of function $\Phi\beta$ for a series of β with different coefficients of side slope m. For β ascertained in this way the values of b and h are determined in the customary manner

$$h = \sqrt{\frac{Q}{v(\beta+m)}}, \qquad b = \beta h$$

When putting together the formulas for calculations, C has been taken to be equal to $(1/n)R^6$.

P. K. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4567. Levitskii, B. F., Determining the boundaries of flooding of the surface jump (in Russian), *Nauch. zap. L'vovsk. politekhn. in-ta* no. 31, 109–113, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 521.

A function is proposed for the value of the piezometrical height h_0 under the stream when descending from the ledge and the moment of flooding of the surface jump

$$h_0 = 0.815\sqrt{\frac{q^2}{gh} + \frac{1}{2}h^2}$$

where h is thickness of the stream on the ledge, q specific discharge, g acceleration of gravity.

The function was obtained by application of the principle of quantitative movement to the section bounded by the free surface of the stream, by the horizontal plane at the level of the ledge, and by two vertical planes—one cutting the stream on the ledge, at a distance of from $1.5h$ to $2h$ from the edge of the ledge, and the other going through the point of bend of the stream where its steepness is at its maximum. In both the vertical boundary sections it is assumed that the hydrostatic principle of distribution of pressure is in operation, while in the horizontal boundary section the pressure is assumed to be a constant, equal to γh_0. The function appears to be commendable for Froude numbers less than 35.

T. N. Astaficheva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4568. Levitskii, B. F., Calculation of the height of the ledge of spillway dams with a projection (in Russian), *Nauch. zap. L'vovsk. politekhn. in-ta* no. 31, 158–162, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 525.

An experimental function is put forward which was obtained on the bases of the experimental data of D. I. Kumin ["Stresses on upper and lower waters when there is a surface condition," Gosenergoizdat. 1948] and N. N. Belyashevskii [*Izv. in-ta gidrolog. i gidrotekhn Akad. Nauk SSSR* **8**, 1951], for the establishment of a boundary for the formation of a surface jump, in the conditions of a two and three-dimensional problem

$$\frac{h}{h_k} = 0.755\frac{\alpha}{P}\left(\frac{P}{h_k} - 2.30\beta - 0.14\right) + 1.70\beta + 0.54$$

where P is height of the dam spillway, α height of the ledge, h_1 depth in the lower water corresponding to the boundary of formation of the surface jump; h_k critical depth; $\beta = b/B$, where b is width of the spillway, B width of the stream in the lower water. The function is recommendable for α/P values from 0.17 to 0.50 and m values from 0.32 to 0.50.

T. N. Astaficheva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Referativnyi Zhurnal, England

4569. Preobrazhenskii, N. A., and Yuditskii, G. A., Investigation of pulsation pressure on the walls of the sluice gallery of a water conduit (in Russian), *Izv. Vses. n.-i in-ta gidrotekhn.* **54**, 65–77, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 480.

A description is given of experiments to study the pulsation of hydrodynamic pressure on the walls and on the flood gates of a water-carrying gallery of a maritime sluice; also are described experiments of remedial measures to reduce this pulsation. The results of the experiments are expressed in the form of curves showing the relationship between the magnitude of the pressure of pulsation and the amount of the discharge. To reduce pulsation pressures it is recommended to introduce grids in the dam recesses below the flood gates.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4570. Birkaya, A. F., Problem of hydraulic structure of flow in front of an intake installation (in Russian), *Trudi Gruz. n. i. in-ta gidrotekhn. i melior.* **3**, 16, 197–206, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 530.

A short description is given of a transverse circulation developing in front of a lateral water receiver and the phenomena connected therewith. The advantage of a water receiver equipped with "sediment intercepting" galleries is demonstrated; this idea was put forward earlier by N. F. Daneliya and A. F. Birkaya [*Gidrotekhnika i melioratsiya* no. 5, 1950]. O. L. Yushmanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4571. Kumin, D. I., and Yuditskii, G. A., Pulsation of a hydrodynamic load on the grid of the pressure gallery (in Russian), *Izv. Vses. n.-i in-ta gidrotekhn.* **54,** 86–97, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 481.

Experiments are described for the study of the hydrodynamic pressure on a grid placed behind the shield closure of a water-carrying gallery of a marine sluice. The model of the grid possessed a known capacity of free movement, having four supporting connections which took up the pulsation oscillations. In the experiments a proportionality was indicated of the maximum pulsation range to the square of the discharge. Experimental results are shown in curves, indicating the dependence of the magnitude of the hydrodynamic pressure on the grid on the amount of the discharge; also the features of the oscillograph are described.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4572. Gutovskii, E. V., Investigation of the pulsation of the hydrodynamic pressure on the walls of the working locks of a combined hydroelectric station (in Russian), *Trudi Leningr. politekhn. in-ta* no. 177, 34–41, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6632.

The results are given of the investigations of the point pulsation of hydrodynamic pressure on a sluice located in the output section of a water delivery gallery.

The tests were made in the laboratory of the Leningrad polytechnic institute on a model of a turbine block with a working wheel having a diameter of 350 mm.

Measurements of the pressure pulsation were performed with the aid of the usual tenso-generators of ohmic resistance, membrane type, without compensation of the static pressure. The tensometers were placed at three points: one at the delivery edge and two at the downstream edge of the model of the lock. Tests were made for three openings of the lock, at constant level of the upper level and in the absence of a collecting wall at the lock from the side of the lower level.

The oscillograms obtained of the recording of the pulse of hydrodynamic pressure represent the curve of oscillations of a higher frequency superimposed on the low frequency ones.

A statistical method of treating the oscillograms was employed: the mean double amplitude was determined as the arithmetic mean of all the double amplitudes; half the figure of all the maxima and minima occurring on the average each second was taken as the mean frequency; in order to determine the maximum value of the double amplitude (to avoid chance errors) frequency curves were plotted.

Analysis of the experimental material leads author to the following conclusions:

The pressure pulsation on the upper wall of the lock is negligible and the power effect on the lock creates a pulsing flow from the direction of the lower level. Pulsation of the hydrodynamic pressure increases with increasing pressure and the degree of opening of the locks of a water gallery.

The first harmonic of the oscillograms with long-duration oscillations (0.65 – 1.4 sec) reflects variations in the horizons of the water in the lower level, and the second in higher frequency oscillations (0.04–0.075 sec) is a result of the action of local eddies at the lower edge of the lock.

The presence of a wall in the lower level of the lock merely reduces the pulsation amplitude obtained from fluctuations of the water level in the lower level.

N. A. Preobrazhenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4573. Ignatenko, S. I., Calculation for countercurrent dissipator of the open type (in Russian), *Sb. tr. Novocherkas. inzh.-melior. in-ta* **5,** 111–115, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 522.

4574. Squire, H. B., The motion of a simple wedge along the water surface, *Proc. roy. Soc. Lond.* (*A*) **243,** 1232, 48–64, Dec. 1957.

The two-dimensional flow of a stream past a simple wedge partly immersed in water is investigated by linearized theory. The results are expressed in terms of a nondimensional speed $V = U(\rho\alpha/gL)^{1/4}$, where U is the velocity of the stream, ρ the water density, α the incidence of the sloping face, and L the lift on the wedge per unit beam. As the speed increases from zero, the immersion of the wedge increases to a maximum and becomes small at high speeds; the frictional drag increases to a maximum at the hump speed and falls to a constant value at high speeds.

From author's summary

4575. Fortier, A., Head losses in cylindrical pipes of noncircular section and of heterogeneous roughness (in French), *Houille blanche* **12,** A, 325–331, May–June 1957.

It seems well established now that, in a turbulent flow, the distribution of mean velocities u, near a wall and along a normal to it, depends only on the friction velocity u_* and a friction coefficient ku_*/ν. Whatever the value of this coefficient, u/u_* is a logarithmic function of the distance from the wall.

Based on these results, it is possible to show that: (1) in general, the friction velocity varies little around the perimeter of any cylindrical section pipe of consistant roughness; (2) the pressure loss formula as applied to any cylindrical pipe of consistant or heterogeneous roughness is the same as the pressure loss formula for pipes of circular section, provided that a "mean relative roughness" factor is introduced, which it is possible to calculate by graphic means, and a form factor from which one can evaluate the magnitude.

From author's summary

4576. Ruchimskii, M. N., Experimental investigation of the compensating capacity of disk-shaped compensators (tube conduits), (in Russian), *Trudi vses. n.-i- in-ta po stru-vu ob'ektov neft i gazovoi prom-sti* no. 6, 47–60, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2189.

The method proposed by S. N. Sokolov for the calculations of lens compensators is investigated. In investigating the endurance of disk compensators the computation of the anchor ring-shaped envelope is replaced by a computation of a ring-shaped plate, fastened along both the outer and inner contours. It is assumed that the dependence of the axis loading on the sagging of the compensator is represented by a broken line consisting of three parts; in the first part the straight line goes through the beginning of the coordinates with some angular coefficients; after that it is parallel to the axis of the saggings; and, finally, appears as a linear hardening. Basic formulas for the calculations are put forward to determine the minimum thickness of the wall of the wave (disks), the permissible sagging of the compensator, and the forces corresponding to this sagging. Dimensions and types of compensators are indicated; these have been tested for axis compression and internal pressure; also details are given of a special stand which was used to carry out the tests, with the application in individual cases of lever tensiometers. An analysis is given of the results obtained.

L. N. Vasitsyna

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4577. Seitz, F., On the theory of the bubble chamber, *Physics of Fluids* **1,** 1, 2–13, Jan./Feb. 1958.

The "bubble chamber" [see, e.g., Glaser, *Phys. Rev.* **87,** p. 665, 1952; **97,** p. 474, 1955; *Nuovo cimento*, **11,** p. 361, 1954] was suggested and promises to accomplish in the study of high-energy particles what the cloud chamber did in classical nuclear physics. In this instrument, bubbles are formed in a superheated liquid along the path of incident particles. However, the mechanism which accounts for the bubble nucleation is still somewhat in doubt. It was first thought that nucleation is associated with the forces resulting from charges induced by ionizing radiation. A later, more likely, suggestion is that nucleation results from local thermal fluctuations caused by passage of energetic particles.

Author examines such a mechanism in some detail; his own summary is reproduced here:

"An attempt is made to analyze the factors which determine the operation of the bubble chamber. It is concluded that the majority of bubbles in conventional chambers are nucleated by moderately energetic free electrons produced by the incident particles in Coulomb encounters. Nuclei are displaced too infrequently by Coulomb encounters to account for the observed densities of bubbles. The electrons deposit their kinetic energy in highly localized regions which then are the source of explosions which produce bubbles of greater than critical size in a time of the order of 10^{-10} or 10^{-11} sec. The bubbles grow subsequently by evaporation of the fluid. The temperature of the fluid should be sufficiently close to the critical temperature that the energy required to produce the bubble of critical size can be provided by an electron with a range comparable to or less than the diameter of the bubble of critical size. Otherwise the electron will be unable to localize its energy in a sufficiently small volume in any but highly improbable cases. It is also concluded that the viscosity of the liquid plays a very important role in determining the threshold energy for forming a bubble of critical size when it has a value near 1 centipoise or larger."

Note: The importance of the bubble chamber is, in reviewer's opinion, twofold: (1) its use in the research for which it was originally conceived, of course, i.e., as a "bubble chamber;" and (2) the possible use of subatomic radiation in the study of the properties of liquids and very viscous materials, once the triggering mechanism is understood, with applications to the problems of tensile strength and cavitation [see reviewer's comment Paper No. 1, Proc., Symp. Cavit. in Hydro., Philosophical Library, 1957], radiation damage, etc.

P. Eisenberg, USA

4578. Shal'nev, K. K., Pressure and erosion in the region of a collapsing cavitation on a round body (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekn. Nauk* no. 6, 111–120, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 443.

Results are described of experiments for determining erosion and pressure in the cavitation region behind a round cylinder placed in the flat working part of a cavitation tube. Author considers that the impact pressures are dependent on the collapse of the cavity, and not on their joining, while the central pressure in the stationary part of the cavity, if it consists of gas bubbles, is equal to the sum of the pressure of water vapor and the pressure of air, dissolved in the water.

L. A. Epshtein

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4579. Iyengar, K. S., and Richardson, E. G., Cavitation and the solution of gases in liquids, *Nature* **181,** 4619, 1328–1329, May 1958.

4580. Gheroff, W., New method of calculation of hydraulic machines (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 506–516.

New criterion of cavitation is developed leading to vane design method. Design and test details are given for centrifugal pumps, but method is theoretically applicable to turbines. Cavitation parameter is formed by ratio of a wheel circulation to fluid circulation, reducing to ratio of angular velocities of wheel and fluid, and thence to vane geometry. Tests indicate a minimum value of parameter of two, leading to small number of large overlapping vanes. Arguments with respect to inactive vane are not clear to reviewer.

D. G. Shepherd, USA

4581. Kaplan, P., The forces acting on hydrofoils in unsteady motion (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 244–254.

Theory of paper is based on linearized potential flow in the entire flow field and with linearized free surface boundary condition. The lift force and mean wave drag are calculated from Blasius theorem and an energy analysis, respectively. Two oscillatory cases are presented, namely (a) vertical heaving of a foil at constant forward speed, (b) foil moving at constant forward speed in sinusoidal waves. Theory permits computation of the waves generated by the hydrofoil and downwash angle in its wake. Agreement of this theory with towing-tank experiments is claimed to be much better than with quasi-steady considerations.

H. P. Liepman, USA

4582. Miller, G. F., On certain integrals occurring in a hydrodynamical problem, *Proc. roy. Soc. Lond.* (*A*) **243,** 1232, 65–77, Dec. 1957.

Paper develops the mathematical theory of certain integrals involving Bessel functions which occur in the problem of the movement of a planing wedge along a water surface. Tables are given and the methods used to compute them are described.

From author's summary

4583. Kolar, V., Decay of spiral flow (in English) 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2,** 75–79.

Paper describes experimental investigation by means of a photographic technique of the flow in an open channel, in which a swirl (with axis in the flow direction) has been introduced by means of guide vanes. Results show decay of swirl and its relation to the turbulence of the flow.

G. Guderley, USA

4584. Fedyaevskii, K. K., Approximate method for the theoretical determination of derivatives of a transverse hydrodynamic force and a moment of yawing at angular velocity for oblong bodies (in Russian), *Trudi Leningr. korablestroit. in-ta* no. 16, 128–135, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1947.

A method is advanced for the determination of rotating derivatives of a transverse force and moment, based on the stationary hypothesis. When applying this hypothesis the hydrodynamic load, corresponding to the potential flowing around a body by an ideal liquid, is deduced from the general hydrodynamic load. This is based on the circumstance that the force and moment of the natural inertia is taken account of separately through the addition of the inertia of the liquid. The author compares the results with the theoretical data for thin wings of small and large span and then applies them to the bodies of rotation, for which the distribution of the hydrodynamic load is taken into consideration by Karman's approximate theory.

M. D. Khaskind

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Incompressible Flow: Laminar; Viscous

(See also Revs. 4328, 4338, 4546, 4558, 4559, 4569, 4571, 4574, 4581, 4660, 4661, 4667, 4670, 4691, 4696, 4698, 4720, 4723, 4732, 4735, 4744, 4790, 4791, 4812)

Book—4585. Sommerfeld, A., Mechanics of deformable media [Mechanik der Deformierbaren medien], Vol. 2, 4th ed., Leipzig, Akademische Verlagsgesellschaft Geest & Portig K.-G., 1957, xii + 372 pp.

The reader will gain little over the second edition in purchasing this fourth edition of volume 2 of the six volumes covering Arnold Sommerfeld's famous lecture course on theoretical physics which made the University of Munich a mecca to advance students of physics during the years between the wars. The second edition of volume 2 was published in 1947 in the original German revision prepared by Sommerfeld himself. The reader is referred to the excellent review of this volume by C. A. Truesdell [AMR **3** (1950), Rev. 1023].

The fourth edition differs from the second in using dot products and cross products in vector multiplication and in having added to it about ten pages on the theory of the boundary layer and its application to the lift of wings, and two or three pages on the "theory of plasticity" with several figures illustrating dislocation patterns in crystals. No reference is made to the modern theory of plasticity which has been developed during recent years into a powerful tool for the solution of problems in the strength of materials and structures stressed far beyond the elastic range.

The paper used in printing the book is unfortunately of the inferior quality characteristic of most East German publications

W. Ramberg, USA

4586. Pykhteev, G. N., An exact solution of the problem of Kirchhoff flow past one two-parameter family of curved obstacles (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, **2,** 1957; 207–214.

An exact solution in closed form is presented for the problem of a two-dimensional discontinuous Kirchhoff flow of an ideal incompressible fluid past a certain family of curved arcs between two parallel walls. The family of arcs depends on three parameters, while the width of the tunnel is also expressed in the same parameters.

When one of the parameters approaches zero, the width of the tunnel tends to infinity and the case of an ideal incompressible fluid past a given obstacle in an infinite domain is obtained. When another parameter tends to zero, the family of curved arcs becomes a straight line perpendicular to the direction of the flow at infinity. By aid of function theory the shape of the free boundary and the resistance of the curved arcs are obtained.

The flow configuration being symmetrical with respect to the axis of the tunnel, the free boundaries can have different structures according to the values of the parameters viz: (1) the free boundaries have a point of zero curvature; (2) they approach the axis of the tunnel asymptotically; (3) they intersect and go over to the second sheet of the Riemann-plane.

E. M. de Jager, Holland

4587. Dumitrescu, L., and Stanescu, C., A boundary-value problem and its applications to the motion of two viscous fluids in contact and to the torsion of a nonhomogeneous rod (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2,** 2, 1957.

Paper consists of two parts. The first one deals with the laminar one-dimensional flow of two viscous fluids of different densities through the same conduit; the problem is reduced to an integral equation. Results may also be applied to the flow of a liquid with free surface, taking into account friction with the air. Applications of general results are given in two cases: (1) the circular conduit through the upper and lower halves of which different liquids are flowing, and (2) the same for a rectangular tube. Numerical examples are given for the cases of water and benzene and of water and air.

In the second part of the paper the same methods are applied to the torsion of a circular-section rod made of two different materials each occupying half of the section. Maximum values of stresses and torsional stiffness are given.

Staff, Revue de mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4588. Maruhn, V. K., The existence of steady-state motions of vortex wings (in German), 9th Congrès intern. Mécanique appl., Univ. Bruxelles 1957; **2,** 173–176.

The internal structure is studied of a toroidal vortex ring in steady motion. An integral equation is obtained which could be solved by iteration to yield the vorticity distribution in the cross section of the torus, as well as translational velocity along axis of symmetry.

Reviewer believes the paper to be basically sound although difficult to follow because of (1) absence of a diagram, (2) several misprints, and (3) a confusing notation (ζ appears to bear two different meanings, while c and r appear to be interchangeable).

A. H. Armstrong, England

4589. Louis, Jean F., Rotational viscous flow (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 306–317.

The method of Hawthorne [AMR **8** (1955), Rev. 1419] for the incompressible flow around two-dimensional bodies in a nonuniform flow is refined by taking the diffusion of vorticity into account.

The flow is assumed to be the sum of the basic nonuniform (viscous) flow, the potential flow around the bodies, and a small perturbation. Expressions for the components of the added vorticity are derived by extensive manipulation of the equations of motion during which a number of terms are discarded as small. The expressions involve integrals of the viscous and potential flows along streamlines which must be evaluated numerically.

The theory is applied to a compressor cascade in the turbulent wake of a flat plate but there is no justification given for applying the theory to turbulent flow. Reviewer believes that application can be justified for fully developed turbulence but that there may be an appreciable error in the transitional range. Also, to be consistent with the coordinate system, y should be replaced by Z in the quoted expression for the velocity distribution.

The results of the present theory are shown to be in closer agreement with experiments at Re^2 10^6 than those of the inviscid theory for this problem.

Reviewer recommends the typographical devices used to indicate vanishing and cancelling terms in lengthy equations to authors and editors.

W. Squire, USA

4590. Walton, J., Note on a source in a rotating fluid, *Quart J. Mech. appl. Math.* **11,** 2, 208–211, May 1958.

The effect of introducing an irrotational source into a rotating fluid has been studied by Barua. In this note, results are obtained which are based on a different hypothesis from that of Barua's. The relation between the maximum flow rate which the source achieves and the speed of a long wave on the surface dividing two régimes of flow is also pointed out. A numerical solution is found for the shape of this dividing surface by means of relaxation methods.

From author's summary

4591. Mohr, W. D., Saxton, R. L., and Jepson, C. H., Theory of mixing in the single-screw extruder, *Indust. Engng. Chem.* **49,** 11, 1857–1862, Nov. 1957.

The performance of the single-screw extruder as a mixing device is studied. The index of the efficiency of mixing, the striation

thickness, is calculated by assuming the laminar flow in the extruder to be a combination of plane Poiseuille and plane Couette flows. Equations are then developed to show the effects of screw design and operating variables on the efficiency of mixing.

C.-S. Yih, USA

4592. Jones, J. P., The calculation of the paths of vortices from a system of vortex generators, and a comparison with experiment, *Aero. Res. Counc. Lond. curr. Pap.* no. 361, 11 pp. + 5 figs., 1957.

The motion of a row of counter-rotating pairs of vortices close to a surface is calculated, using two-dimensional inviscid theory. Results are compared with observations in a small water tunnel. Agreement is reasonable in plan view; distance between vortex trail and plate is given too high by theory.

L. J. F. Broer, Holland

4593. Reichardt, H., Manifolding a pipe in order to distribute the flow rate into prescribed fractions (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 17, 49 pp., 1957.

Continuing his previous work on manifold problems, author derives new equations for calculation of throttling apertures at both ends of perpendicular channels connecting two horizontal mains. Equations derived under simplifying conditions have been experimentally verified. Tests have been carried out with air on 25 parallel rectangular channels and on 10 tubes (2.5-cm diam) imitative of a coke-oven system.

O. Mastovsky, Czechoslovakia

4594. Wigley, C., The effective virtual mass of a spheroid moving near the free surface of a fluid (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles 1957; **1**, 203–206.

The purpose of this paper is to put on record some experimental results with a spheroid moving, totally submerged, below the free surface of a fluid. From these it is possible to deduce some information as to the effective virtual mass for vertical motion.

From author's summary

4595. Bakhmeteff, B. A., and Feodoroff, N. V., Patterns of flow through horizontal slits (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles 1957; **1**, 221–234.

Experiments disclosed the physical features of the surface profiles in transition from rapid to tranquil motion. Some of the forms of the outflowing veins are of such nature that complementary phenomenological types had to be added to the accepted basic transition forms. The outflowing veins were investigated from free flow to complete submergency.

From authors' summary

4596. Brower, W. B., A linearized theory for the normal force on closed bodies of revolution (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 439–448.

Method is suggested for determining normal force on a thin closed body of revolution when placed in an irrotational flow with its axis of symmetry inclined at small angle to direction of stream. Author employs mathematical model related to that used by von Karman in which a vortex sheet is assumed to emanate from zero-meridian line aft of section of maximum diameter. Vorticity is determined by a certain boundary condition placed on transverse flow. The validity of this boundary condition remains open to further investigation. Actual computation is carried out by means of electric-tank analogy and applied to a paraboloid of revolution. Comparisons with other results are given.

G. Power, England

4597. Haberman, W. L., Wall effect for rigid and fluid spheres in slow motion (in English), 9th Congrès intern. Mécan. appl., Univ. of Bruxelles, 1957; **3**, 210–225.

Problem of steady axial translation of rigid and fluid spheres in a viscous, incompressible fluid bounded by an infinitely long cylinder is considered. Investigation is based on Stokes's approximation for the hydrodynamic equations for slow motion.

Exact solution for the motion of rigid spheres is obtained in terms of an infinite set of linear algebraic equations for the coefficients in the Stokes stream function. Drag of spheres is determined numerically over a range of ratios of sphere to cylinder diameter. It is shown that the first two equations of the infinite set provide a simple and close approximation to the motion and drag of rigid spheres over a large range of diameter ratios.

For fluid spheres (i.e., spheres which have different physical properties than the external medium and are characterized by internal motion) an approximate solution (similar to the one for the rigid case) is obtained. Experimental results for the rigid and fluid case confirm the theory. In general, the results show that wall effect for fluid spheres is less than for corresponding rigid spheres.

Streamlines and velocity distributions for cases where diameter ratio is 0.5 are compared with those in an infinite medium.

From author's summary by N. Tetervin, USA

4598. Abbasov, A. A., Kasimov, A. F., and Mirzadzhanzade, A. Kh., The displacement of a viscous liquid by another in a vertical round cylindrical tube when the liquid movement is laminar (in Russian) *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 3, 167–169, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1969.

An attempt is made to investigate theoretically the problem indicated in the title. An approximate method of solution is adopted, analogous to the method of laminar movement used in subterranean hydrodynamics when investigating the changing boundary of the division of two liquids. It is shown that the given method obviously does not fit in with the facts, but the results obtained permit the qualitative study of the process to a certain degree. It is accepted that the curve of velocities when one viscous liquid is being forced out by another remains the same as for the movement of a homogeneous liquid when the boundary conditions are identical. A differential equation is obtained of the first order in non-dimensional variables, which integrates. Using the results of the numerical calculations, a graph is constructed for six different cases of displacement of petroleum by water.

There are misprints in the article. A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4599. Semikin, I. D., and Gol'dfarb, E. M., Theory of free flow (in Russian), *Nauch. tr. Dnepropetr. metallurg. in-ta*, no. 31, 3–15, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1975.

Differential equations are obtained determining the spreading of the plane and axial symmetrical laminar stream in an unbounded medium with the same physical properties. Formulas are given for the distribution of velocities in cross section and along the stream axis. It is shown that the nondimensional profiles of velocity become similar, commencing from some fully determined value of the time factor. The calculations, carried out on the basis of the obtained relations, confirm satisfactorily the experimental data of I. D. Semikin [*Nauch. tr. Dnepropetr. metallurg. in-ta* no 14, 1948]. It has to be noted, however, that the formulas submitted by the authors conform with the first approximation of the solution of the problems obtained by Pai [*Mekhanika. Sb. nerev. i obz. in. period. lit.* no 1, 1950; *Quart. appl. Math.* **10**, no. 2, 1952].

M. M. Benilova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4600. Levin, A. M., Calculation methods for gas pressures in networks of low pressure (in Russian), *Gazovaya promst.* no. 1, 24–30, 1956; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1735.

The possibility is examined of raising the pressure of the gas in

domestic gas-consuming installations in order to secure economy in the pipe system of gas distribution. I. A. Shepelev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4601. White, T. T., Flues for appliances with room-sealed combustion chambers: some theoretical considerations, *J. Inst. Fuel* **30,** 203, 646–661, Dec. 1957.

A very comprehensive treatment on ventilation of gases from appliances with room-sealed combustion chambers is given, correlating theories with experimental data. Mathematical treatment for individual flues is presented with well-derived flow equations and consideration of basic properties of the flue gases (combustion products). A case of single-duct system is used for detailed analysis, which includes all important design criteria and many practical data. Functioning and ventilation of stipulated appliances under inversion conditions is also treated, together with wind considerations. Flow resistance and thermal transmittances of the flue systems are discussed. A number of applicable references are used in the mathematical derivations. A list of the references is attached.

This article is of considerable interest to all engaged in ventilation and gas disposal problems. The quality of presentation is high and the organization of the presented material is competent.

C. R. Bell, USA

4602. Benson, R. S., Discharge from an engine cylinder to atmosphere, *Engineer, Lond.* **203,** 5291, 946–948, 1957; **203,** 5292, 976–978, 1957.

The discharge of gas from a cylinder to atmosphere in a running engine with variable cylinder length is analysed by the method of characteristics; also both outflow and inflow through piston-controlled exhaust ports. The analysis confirms that the mode of discharge is by wave action which persists even after the discharge process is over. An experimental investigation on a running engine is described. The experiments confirmed the results of analysis. Experiments show that a depression of the magnitude claimed by Kadenacy could be obtained on an engine with no exhaust appurtenances; these effects can be explained by classical gas dynamics. It is, however, concluded that the enhanced performance of engines running on the Kadenacy system is explained by the high rate of port opening associated with large depressions rather than by the depression itself. Of special interest is the application of the graphical method of characteristics, comprising a "position diagram" expressing piston position versus crank angle (i.e., time), and the "state diagram" expressing the pressure-velocity state for the various positions. Experimental set up is described in detail; the light-spring indicator diagrams were taken with a Farnborough indicator, with Thyratron relay circuit. Previous work of other investigators is reviewed.

K. J. DeJuhasz, Germany.

4603. Dimmock, N. A., An experimental introduction to the jet flap, *Aero. Res. Counc. Lond. curr. Pap.* 344, 28 pp. + 46 figs., 1957.

This paper records the experimental results obtained with two two-dimensional airfoils, each having a 12.5% thick elliptical cross section with a narrow full span jet slot at the trailing edge, the jet deflections being, respectively, 90° and 31.4°. It is shown that the values of the force and moment coefficients and derivatives obtained experimentally agree satisfactorily with those suggested by the theory of B. S. Stratford [*Aero. Quart.* **7,** Feb., May, Aug. 1956]. Support is given to the thrust hypothesis in that the measured thrust was greater, under appropriate conditions, than the reaction component from the deflected jet. The losses in the system have been considered and some of them investigated, those due to Reynolds number and jet entrainment effects being included. Also, the influence of ground proximity on the lift and center of lift of the 31.4° model was measured at zero incidence and found not to be prohibitive. A tentative empirical expression is suggested for the pitching moment coefficient.

From author's summary

4604. Dimmock, N. A., Some further jet flap experiments, *Aero. Res. Counc. Lond. curr. Pap.* 345, 22 pp. + 45 figs., 1957.

This paper, which may be considered as an addendum to the N.G.T.E. Report R.175 [see preceding review], records the results on the same two-dimensional airfoil which was used for the earlier work and which had a 12.5% thick elliptical cross section with a narrow full span jet slot. This time, however, the jet deflection is 58.1° from the chord line. In addition to the measurement of the forces and moments acting on the model, the flow pattern in the vicinity of the airfoil was revealed with smoke filaments and was recorded photographically. A comparison with the theory of B. S. Stratford [*Aero. Quart.* **7,** Feb., May, Aug. 1956] is drawn where appropriate and additional support is given to the thrust hypothesis. A check on the effects of Reynolds number variation and of the addition of transition wires to the model confirmed the results of the previous experiments, while the influence of ground proximity on the lift, center of lift position, and the thrust was investigated and found to be substantial, although a reason is suggested why these results might be pessimistic.

From author's summary

4605. Edmunds, D. E., The moving aerofoil in shear flow in the neighbourhood of a plane boundary, *Quart. J. Mech. appl. Math.* **10,** 4, 448–464, Nov. 1957.

Author discusses the problem of finding the forces acting on a two-dimensional airfoil moving near a plane boundary in incompressible inviscid fluid which is in linear shear flow parallel to the boundary. To do this, the extension of Green's method [AMR **2** (1948), Rev. 885] used in author's previous paper [AMR **10** (1957), Rev. 4059] is employed. Expressions are obtained in series form for the forces and couple acting on a fairly general type of airfoil, and especially the simple case of a flat plate airfoil is considered in more detail.

From author's summary by S. Tomotika, Japan

Compressible Flow, Gas Dynamics

(See also Revs. 4653, 4673, 4692, 4702, 4704, 4705, 4706, 4707, 4708, 4713, 4739, 4776)

4606. Germain, P., Some recent progress in aerodynamic theory for high speed (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles 1957; **1,** 5–43.

Author represents his lecture at the opening session of the Congress in September 1956: very interesting and objective information of recent sonic, transonic and supersonic flow theories; two- and three-dimensional problems (methods and results) published by about 60 authors of the western world during the past 10 years. This nearly complete review of linearized small-perturbation theories (Laplace equation, and second-order approximation aspects, method of iteration) of the frictionless steady flow, including unsteady flow problems in some cases also, gives reviewer no other chance than to cite some of the most important problems. These are, first, lifting-surface theory with subsonic or supersonic leading edge, and methods to determine and reduce zero-lift wave drag in dependence of thickness-distribution. Then follow theories for low-aspect-ratio pointed wings and slender pointed bodies of revolution, as well as linear conical flow field theory, as successful methods of calculation for steady transonic and lower supersonic flow and, as a consequence, transonic similarity laws and equivalence theorem for pressure distribution and wave drag (transonic area rule). As a consequence of such a review, references have to be understood as ex-

amples and not ever as the origin of the theory or the principal idea; it is the character, the kind, and the development, and last, but not least, the language of this paper, which make it important and very interesting. F. Keune, Germany

4607. Krzywoblocki, M. Z. v., On the generalized integral operator method in the subsonic diabatic flow of a compressible fluid (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 414–419.

Bergman's method of linear integral operators is generalized and applied to solve the system of linearized equations in the hodograph plane for the diabatic subsonic flow of a perfect, non-heat-conducting fluid, with sources or sinks of heat in the flow field. Author shows that the stream-function equation, the method of solution, and the domain of uniform convergence are formally the same as those for the adiabatic subsonic flow (original Bergman method). Various applications to practical problems will be discussed in another paper (to be published).

G. Sestini, Italy

4608. Matunobu, Y., and Takami, H., Studies of the two-dimensional high subsonic flow by approximation methods (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 426–433.

Authors apply (part I) the transonic thin-wing-expansion method to determine the high subsonic two-dimensional, irrotational flow of a compressible fluid past a Kaplan bump and past an elliptic cylinder. The approximate expression for the velocity distribution is obtained and the order of the approximation is given. The Karman-Tsien method, Wentzel-Kramers-Brillouin (W.K.B.) method, and modified M^2-expansion method are applied (part II) to the study of the compressible flow past a Cherry profile and past a Tomotika-Tamada profile. Numerical results are compared with the exact hodograph solution. Eight very expressive figures and twenty four references complete the paper.

G. Sestini, Italy

4609. Rogers, E. W. E., and Berry, C. J., Experiments at M = 1.41 on elliptic cones with subsonic leading edges, *Aero. Res. Counc. Lond. Rep. Mem.* 3042, 18 pp. + 2 tables + 53 figs., 1957.

Tests have been made at a Mach number of 1.41 on six elliptic cones forming two families of models. In the first, the vertex angle in the plane of the major axes of the elliptic cross sections was maintained constant at 60° and the ratio between the minor and major axes varied; in the second family, the minor axis was constant and the vertex angle had values of 30°, 60° and 90°. Two cones from the first family were pressure-plotted at incidences up to 15°, the resulting pressure distributions being integrated to give the lift and pressure drag arising from the curved surfaces of the cones. Except for one of the pressure-plotting models, lift, drag and center-of-pressure position were measured for all models on a strain-gage balance. For the one cone on which a comparison was possible, good agreement was obtained for the lift and drag derived from the two methods.

The distribution of pressure on the two pressure-plotting cones was found to be approximately conical in form (*i.e.*, constant along the cone generators), and at 0° good agreement with theory was obtained. At incidence, the agreement was worse and deteriorated when, at the higher incidences, transonic-type shock waves appeared on the upper surfaces of the cones. These shock waves which lay along a cone generator moved inboard with increase in incidence, and vortices, formed from flow separating from near the leading edges, also appeared, with a consequent modification of the upper-surface pressure distribution. These transonic-type shock waves were observed by using optical systems of schlieren or shadowgraph type, but with the light beam passing obliquely through the tunnel so that it was approximately parallel to the shock front; the separation vortices were detected by observing the motion of an oil film on the surface of the models.

Good agreement was obtained between linear (flat-plate) theory and experiment for the lift of the family of cones having a 60° vertex angle; there is only a small effect on the lift-curve slope due to increasing the cone thickness (*i.e.*, the minor axis of this family). The surface shock waves and separation vortices were responsible for a change in the rate at which the drag of the cone family increased with the lift.

The comparatively slender cone of the other family had a lift curve which was markedly nonlinear at the higher incidences and this effect was attributed to the presence of separation vortices.

The inclination of the cone-like shock originating at the vertices of the models and also the distribution of pressure over the bases of the cones were measured.

From authors' summary

4610. Taylor, C. R., A subsonic lifting-surface theory for low aspect-ratio wings, *Aero. Res. Counc. Lond. Rep. Mem.* 3051, 9 pp. + 5 tables + 11 figs., 1957.

4611. Jones, R. T., and Van Dyke, M. D., The compressibility rule for drag of airfoil noses, *J. aero. Sci.* **25**, 3, 171–172, 180, Mar. 1958.

In purely subsonic compressible inviscid flow, the drag of any semi-infinite airfoil section is obtained by applying the Prandtl-Glaubert correction to the drag for the corresponding incompressible problem. The result for the parabola can be used to correct thin airfoil theory in the neighborhood of the stagnation point.

A. R. Mitchell, Scotland

4612. Moore, C. A., Jr., and Kline, S. J., Some effects of vanes and of turbulence in two-dimensional wide-angle subsonic diffusers, *NACA TN* 4080, 83 pp. + 14 tables + 36 figs., June 1958.

Tests on two aspects of the behavior of wide-angle, plane-walled, two-dimensional diffusers with essentially incompressible flow have been conducted. A thorough study of the flow mechanism has been made using dye injection in a water table. The four regimes of flow found are delineated on graphs in terms of the three important parameters. Test data from large and small water-table units are given. Data are also presented which demonstrate means for producing efficient diffusers with total included angles up to 45° by use of simple, short, flat vanes.

From authors' summary

4613. Whitcomb, R. T., A fuselage addition to increase drag-rise Mach number of subsonic airplanes at lifting conditions, *NACA TN* 4290, 9 pp. + 1 table + 7 figs., June 1958.

The addition of fuselage volume on the top of the forward portion of the fuselage for the purpose of increasing the drag-rise Mach number of subsonic airplanes at lifting conditions is investigated. The additions have been designed on the basis of the area rule and other important considerations to provide greater practicability of application compared with shapings previously investigated. The addition increased the drag-rise Mach number by an increment of approximately 0.03 for a configuration having a wing with moderate thickness and 35° of sweepback at a lift coefficient of 0.3. A lesser increase was obtained for a configuration with a thicker wing. The additions increase the nonlinearities of the variations of pitching moment with lift.

From author's summary

4614. Messiter, A. F., Jr., Expansion procedures and similarity laws for transonic flow, Cal. Inst. Technol. Guggenheim Aero. Lab., AFOSR TN-57-626, 105 pp., Sept. 1957.

The transonic flow past slender bodies and thin wings is investigated with the use of a general theory of expansion procedures. It is assumed that the solutions for the velocity components pos-

sess asymptotic expansions of a very general form, and the differential equations and boundary conditions for the first and higher approximations are obtained by applying appropriate limiting procedures to the full equations. The following cases are treated: (1) bodies of revolution at zero incidence; (2) bodies of nearly circular cross section, at zero incidence; (3) bodies of revolution at an angle of attack; and (4) thin wings at zero incidence. Certain first-order similarity laws are derived for these problems, and the order of magnitude of the error is stated in each case.

From author's summary by T. Gullstrand, Sweden

4615. Maeder, P. F., and Thommen, H. U., Linearized transonic flow about slender bodies of revolution at zero incidence, Brown Univ., Div. of Engng. TR W725, 73 pp. + 39 figs., July 1957.

Following Oswatitsch and Keune [AMR **10,** (1957), Rev. 1160] authors try to approximate perturbation velocity potential φ by substituting constant for φ_{xx} in nonlinear term $\varphi_x\varphi_{xx}$ of differential equation (x = coordinate in stream-wise direction). However, restriction of original work to forebody region is not upheld, for reasons not clearly stated. Solution is given for body of general form and for arbitrary Mach number M_∞.

Two ways of choosing the constant for φ_{xx} are considered. (1) It is taken equal to computed value of φ_{xx} at point at surface where φ_{xx} vanishes as $M_\infty \to 0$. (2) It is taken equal to computed value of φ_{xx} at computed sonic point at surface. Reviewer notes that (1) seems artificial for $M_\infty \geq 1$ since the point selected in general will be located behind the limiting Mach wave. A large wind-tunnel program measuring drag of circular arc bodies with different wall configurations indicates that, for walls believed best, choice (1) gives better agreement than (2) for type of body considered. S. B. Berndt, Sweden

4616. Harder, K. C., and Klunker, E. B., On slender-body theory at transonic speeds, *NACA Rep.* 1315, 6 pp., 1957.

After a brief consideration of subject theory, the transonic area rule for configurations with a fixed base contour is deduced.

G. E. Nitzberg, USA

4617. Vaglio-Laurin, R., and van Dyke, M. D., A discussion of higher-order approximations for the flow field about a slender elliptic cone, *J. Fluid Mech.* **3,** 6, 638–644, Mar. 1958.

The method of linearized characteristics has appeared to be useful for determining the pressure distribution on non-axially symmetric bodies, for example. It has been criticized by Van Dyke [*J. Fluid Mech.* **1,** no. 1, 1956] on the basis of a comparison of the results obtained for an elliptic cone of 3 : 1 axis ratio at $M = \sqrt{2}$ by second-order slender-body theory and by applying to this theory the approximation procedure inherent in the linearized characteristics method (linearizing with respect to deviation of the cross section from circular). In the first part of present paper, Vaglio-Laurin shows that, provided an area-rule requirement is satisfied, reasonably good results can be obtained from linearized characteristics even for the above relatively unfavorable case. Van Dyke concedes this in second half of paper but maintains superiority of second-order slender-body theory (supported by some experimental results) and repeats criticism of unmodified method.

Reviewer feels that subject is left in a somewhat unsatisfactory state. H. C. Levey, Australia

4618. Lord, W. T., and Hastings, R. C., Some continuous transitions from symmetrical two-dimensional to axial axisymmetrical compressible flows (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles 1957, **2,** 80–87.

Authors deal with compressible inviscid and irrotational isentropic flow patterns which depend on two independent variables and a parameter a. This parameter a varies from $a = 0$ (axisymmetric flow past a body of revolution) to $a = \infty$ (plane flow past a wing). If $0 < a < \infty$, one gets an axisymmetric flow around a ring body. For such flow patterns velocity potential, stream function, velocity vector, and density are developed as power series of a parameter depending on the shape of the ring. Authors succeed only in establishing the first three terms of the series. Applications to transonic flow through nozzles and to supersonic flow past slender bodies verify known results.

Some rather general ideas are outlined about similar procedures in the case of three-dimensional flow patterns with two planes of symmetry. It is not possible to see if such procedures may be useful for any practical problem. R. Sauer, Germany

4619. Hearth, D. P., and Connors, J. F., A performance analysis of methods for handling excess inlet flow at supersonic speeds, *NACA TN* 4270, 10 pp. + 1 table + 15 figs., May 1958.

For the Mach 1.5 to 4.0 range, the following schemes were considered: normal- and oblique-shock spillage, bypass through an auxiliary exit, bypass to an ejector nozzle, and bypass through an auxiliary ramjet engine. These methods were evaluated in terms of a thrust penalty for an assumed turbojet engine. Charts are presented for estimating these penalties for a range of mass flows and Mach numbers. Comparison of the various methods is also made on the basis of matching requirements for a hypothetical Mach 4.0 turbojet application. From authors' summary

4620. Oswatitsch, K., Extreme speeds and thermodynamic states in supersonic flight, *NACA TM* 1434, 30 pp. + 6 tables + 10 figs., Apr. 1958.

Translation of *Z. Flugwiss.* **4,** 3/4, 1956 [AMR **9** (1956), Rev. 3676]. Ed.

4621. Cheng, S.-I., An approximate method of determining axisymmetric inviscid supersonic flow over a solid body and its wake, *J. aero. Sci.* **25,** 3, 185–193, Mar. 1958.

A simple approximate method is described for determining a supersonic axisymmetric flow over a pointed nose body of revolution and its wake. The method is applied to an ogive cylinder of slenderness ratio 3 and Mach number 3, and the surface pressure coefficient calculated over the front end of the ogive. The results agree well with the characteristic solution. It is claimed that the method is applicable to regions where the streamlines converge, but so far no check on the accuracy of the method has been made in such regions.

A. R. Mitchell, Scotland

4622. Lomax, H., and Sluder, L., A method for the calculation of wave drag on supersonic-edged wings and biplanes, *NACA TN* 4232, 24 pp., Mar. 1958.

Writers consider the wave interference problem in supersonic flow for some simple models. To simplify the analysis, only the linearized wave equations are applied. In a two-dimensional flow they consider interference between wings (straight line segments) in any number of planes (biplane, etc.). The technique is a straightforward one. In a three-dimensional flow the following models are treated: single wing and biplane with supersonic leading edges and trailing edges normal to the free-stream direction. These cases have been solved previously but the way of attacking the problem was different. Some remarks on the optimum two-dimensional lifting systems and drag for fixed wing volume close the report. M. Z. v. Krzywoblocki, USA

4623. Theodorides, P., The shock wave in a non-monatomic fluid, Inst. Fluid Dynam. appl. Math., Univ. Maryland TN BN-123, 20 pp., Feb. 1958.

Normal shock profiles are computed assuming two bulk viscosities. Shock strengths were low enough that disassociation is negligible, although activation of a vibrational mode is considered. Bulk viscosity moduli ($k = 2 + 2\mu/3$) of 0 and 0.8 were used. The larger value of k increased shock thicknesses by 40–45%. Calcu-

lations are based on the NBS tables of gas properties. The frozen state temperature immediately behind the shock is compared with the final equilibrium temperature. S. H. Maslen, USA

4624. Kogan, A., An application of Crocco's stream function to the study of rotational supersonic flow past airfoils, *Quart. J. Mech. appl. Math.* **11,** part 1, 1–23, Feb. 1958.

Problem is studied by a method of successive approximation by using as the zero-order approximation the undisturbed flow in one case and the flow behind a plane shock wave in another. As typical of such methods of approximation, success is measured by comparison with results of other investigators by other methods. Similar results of others check these calculations.

H. G. Lew, USA

4625. Margolis, K., Malvestuto, F. S., Jr., and Maxie, P. J., Jr., Theoretical calculations of supersonic wave drag at zero lift for a particular store arrangement, *NACA TN* 4120, 28 pp. + 1 table + 8 figs., Jan. 1958.

An analysis, covering the complete range of supersonic Mach numbers and based on the linearized thin-airfoil theory, has been carried out for the wave drag at zero lift of a simple two-body arrangement consisting of two wedgelike surfaces, each with a rhombic lateral cross section and emanating from a common apex. It was found that by orienting the axes of the bodies relative to one another a given volume may be redistributed in a manner which enables the wave drag to be reduced in the lower supersonic range. It was also found that at the high Mach numbers the wave drag is always increased. If, in addition to a constant volume, a given maximum thickness/cord ratio is specified, then canting the two surfaces always results in greater wave drag at all Mach numbers. Analogous calculations were performed for the case of two parallel, winglike bodies with the same cross-sectional shapes.

A. J. Chapman, USA

4626. Carafoli, E., and Horovitz, Beatrice, Homogeneous supersonic flow of higher order around a cross-shaped airfoil: Application to oscillatory movements (in French), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 269–282.

Using generalized conical flow theory, introduced by Germain [AMR **3** (1950), Rev. 103 and Rev. 2402], general formulas are derived for the pressure on a cruciform delta wing with subsonic leading edges, the prescribed downwash on the horizontal plane and the prescribed sidewash on the vertical plane being homogeneous polynomials of arbitrary degree in the geometrical variables. As an illustration of the theory some applications have been made to stationary flow examples. Another application of the theory is given by the calculation of the pressure on the cruciform wing, performing rotational oscillations about the intersection of the horizontal and the vertical plane.

E. M. de Jager, Holland

4627. Nikol'skii, A. A., On the lift and induced drag of a wing-body system (in Russian), *Prikl. Mat. Mekh.* **21,** 2, 189–194, 1957. (Translated from Russian by M. D. Friedman, 67 Reservoir St., Needham Heights, Mass., N-102, 6 pp.)

Paper is concerned with the total lift on a wing-body combination at small incidence when the drag due to lift is a minimum. Under certain restrictions the results are applicable to both subsonic and supersonic flow. For the special case of a wing mounted on a pseudo-circular body, where the body diameter and wing chord are both small compared with the body length, it is shown that the ratio of the lift supported by the wing to the total lift on the wing-body combination is a simple function of the body diameter/maximum span. Also given is the optimum distribution of circulation over the wing for a given body diameter/maximum span, although the necessary wing camber and twist for a given planform is not considered.

This novel method of treatment is based on the representation of the circulation as a function of the axisymmetric stream function which is evaluated for the flow around the body alone at zero incidence. For small wing-body incidences it is then assumed that the free vorticity shed from the wing and body will lie along these streamlines. Since the optimum circulation around the vortex sheet far downstream is elliptic, it is then shown that the optimum lift is proportional to the circulation at the axis and the square root of the stream function corresponding to the extremities of the circulation distribution. The author states without proof that these results can be extended to nonplanar wing-body combinations such as high- or low-wing arrangements and to the case of an annuler wing on a circular body. In the latter case he states, without proof, that the total lift on the wing-body combination is less than that supported on the wing.

A small number of minor errors exist in the translation. For instance in Eq. [12] the term in $\bar{z}^2$ should read $4\bar{z}^2$.

G. M. Lilley, England

4628. Carafoli, E., and Horovitz, B., High-order conical flow around triangular wings fitted with normal plate (in French), *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2,** 2, 1957.

Supersonic flow around triangular wings fitted with normal plate is dealt with within the theory of high-order homogeneous motions. The disturbance velocity components, normal to the wing and plate respectively, are given in the form of homogeneous polynomials of the $n-1$ order. The problem is to determine the expressions of the axial component u on the wing and plate; these expressions are set as a function of a certain derivative of the $n-1$ order of the component u; the derivative satisfies such boundary conditions that it may be readily determined.

A practical application is given, consisting of a second-order homogeneous flow around a cruciform wing.

Staff, Revue de Mecanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4629. Carafoli, E., and Ionescu, M., High-order conical flows around thin or thick triangular wings (in French), *Acad. Repub. Pop. Romane, Rev. Mĕcan appl.* **2,** 2, 1957.

High-order homogeneous flow around a ridge separating two regions of different downwash distribution is dealt with on the basis of a hydrodynamic analogy. Solution is obtained by placing along any ridge a series of singularities as required by the physical flow conditions in its immediate proximity. These singularities have a hydrodynamic character and are reproduced in a conveniently chosen plane. In this way problem is reduced to the elementary one of a two-dimensional motion. Thus the general expression of the axial disturbance velocity for a thick or thin wing with subsonic or supersonic leading edges is obtained.

Solution for an arbitrary homogeneous flow is also indicated.

Staff, Revue de Mecanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4630. Plascott, R. H., Measurements of the paths of the vortex cores shed from the wings of a typical guided-missile model at M = 1.57, *Aero. Res. Counc. Lond. Rep. Mem.* 3016, 8 pp. + 26 figs., 1957.

The paths of the cores of the vortex sheets shed from the wings of a typical guided-missile model, having cruciform rectangular wings mounted on a long cone-cylinder body, have been traced in their movement downstream over a range of incidence and yaw from 5° to 20° and 0° to 20°, respectively, at $M = 1.57$.

The measurements have shown that:

(a) the cores of the vortex sheets remain very close to the plane parallel to the free stream containing the line of the mid-chords of the wings from which the vortex sheets are shed;

(b) the movement of the fully rolled-up cores in this plane can, for practical purposes, be attributed entirely to the flow induced by the other wing;

(c) estimates of the paths of the vortex cores based on slender-body theory do not agree at all well in the regions investigated owing to the presence of strong shock waves and rapid expansions. Estimates of the paths of the vortex cores based on a semi-empirical analysis have shown reasonable agreement, however, and it is considered that approximations similar to those made in these estimates for this configuration would give reliable values for other configurations in the regions near the wings; well downstream of this region a slender-body theory analysis would probably be satisfactory;

(d) slender-body theory gives a reasonable estimate of the spacing of the cores of the fully rolled-up sheets at the zero yaw condition. Estimates of the characteristics of four rear surfaces using this vortex spacing have shown satisfactory agreement with experiment;

(e) further tests to check these conclusions on a large range of missiles seem desirable. From author's summary

4631. Chernyi, G. G., Hypersonic flow around a body by an ideal gas (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 6, 77–85, 1957. (Translated from Russian by M. D. Friedman, 67 Reservoir St., Needham Heights, Mass., C–111, 13 pp.)

Both plane and axisymmetric cases are considered. Basic equations of motion, continuity, and entropy are first written in a curvilinear coordinate system x, y (x along the body contour, y perpendicular to it). Conditions behind bow shock wave provide boundary conditions and indicate order of magnitude of several parameters of disturbed flow. System is then transformed into new independent variables, the stream function ψ, and the coordinate x. Solution is attempted in form of a special kind of power series in $\epsilon = (\gamma - 1)/(\gamma + 1)$, and first (Newtonian) and second (Newtonian + centrifugal force) approximations are computed by means of quadratures. Determination of the arbitrary functions is practically shown on example of flow around a truncated cone with a central channel. Drag coefficient is also computed in function of a similarity parameter. Shock-wave curvature is shown to decrease rapidly with increasing x, resulting in a thin "entropy layer" on the body surface. Finally, cone and wedge solutions are compared with exact solutions, showing satisfactory agreement.

Paper undoubtedly provides a fundamental contribution to hypersonic aerodynamics. From the engineering standpoint, however, no sufficient physical and mathematical indications are given in the text for a suitable understanding of the theory. Excessive conciseness and a number of typographical errors affecting indices and signs make the paper laborious to study with some profit.
P. Schwaar, France

4632. Fraenkel, L. E., The hypersonic flow of a polyatomic gas past bodies of finite thickness (in English), 9th Congres intern. Mecan. appl., Univ. Bruxelles, 1957, **2**, 255–265.

Paper presents a very similar theory to that of G. G. Chernyi (see preceding review). Also the same example of flow past a truncated open-nosed cone is treated. A careful consideration of the order of magnitude of the quantities involved leads the author to a critical discussion of the validity of the theory, which is found to be severely limited. P. Schwaar, France

4633. Garabedian, P. R., and Lieberstein, H. M., On the numerical calculation of detached bow shock waves in hypersonic flow, *J. aero. Sci.* **25**, 2, 109–118, Feb. 1958.

A method is presented for computing the subsonic inviscid flow behind a detached bow wave which appears in front of a bluff axially symmetric body in hypersonic flow. Particular attention is given to the stagnation-point region.

The form of the shock is assumed and the problem is formulated as an initial-value problem. Such an initial-value problem is, however, not properly set in the usual sense when Cauchy data are assigned along the shock wave arc bordering the subsonic region in a meridian plane, because in this region the flow is described by a stream function which satisfies an elliptic-type partial differential equation. It is shown that, by means of analytic continuation into the complex domain, the Cauchy problem is reformulated in such a manner that it becomes properly set in the subsonic region. A stable scheme for computations by finite differences is, thus, obtained.

Numerical examples at free-stream Mach number 5.8 are presented in which the flow is determined throughout the subsonic region; and, in particular, the detachment distance, the location of the sonic line and the pressure distribution along the body are computed. These results are found to agree very well with experimental data. S. Ostrach, USA

4634. Campbell, I. J., and Pitcher, A. S., Shock waves in a liquid containing gas bubbles, *Proc. roy. Soc. Lond.* (*A*) **243**, 1235, 534–545, Feb. 1958.

Considerations of continuity, momentum and energy together with an equation of state are applied to the propagation of plane shock waves in a gas + liquid mixture. The shock-wave relations assume a particularly simple form when the temperature rise across the shock is neglected. Temperature rise is shown to be small for a very wide range of conditions. It is shown from entropy considerations that a rarefaction wave cannot propagate itself without change of form, and that a compression wave can be expected to steepen into a shock wave. Measurements confirm the theoretical relation for the propagation speed of shock waves.
From authors' summary by J. H. van de Stadt, Holland

4635. Love, E. S., A reexamination of the use of simple concepts for predicting the shape and location of detached shock waves, *NACA TN* 4170, 53 pp., Dec. 1957.

An excellent correlation of experimental data for axisymmetric and two-dimensional symmetric bodies at zero angle-of-attack in supersonic-hypersonic range. Author uses as characteristic length the diameter (or width) of body at "Busemann control point," i.e., point where surface inclination equals detachment angle of cone (or wedge) at that Mach number; detachment distances are measured from the plane containing this point. Data are presented for spheres, cylinders, cone-cyliners, wedge-slabs, and other bodies. Modified Moeckel method using one empirical curve predicts shock shape for spheres, cylinders, and related shapes quite accurately. Real gas effects are not considered at hypersonic speeds ($\gamma = 1.4$). A. E. Bryson, Jr., USA

4636. Feldman, S., Hypersonic conical shocks for dissociated air in thermodynamic equilibrium, *Jet Propulsion* **27**, 12, 1253–1255, Dec. 1957.

Author develops the Taylor-Maccoll equation in a form suitable to obtain the equilibrium flow of a dissociating gas by a numerical integration. Results are given for air at an altitude of 100,000 ft showing surface pressure coefficient and shock-wave angle as a function of cone angle for different free-stream velocities ranging from 1×10^4 to 2.6×10^4 fps. Under the assumption that angular density gradients in the shock layer are small, author concludes that the flow may be regarded as incompressible, in which case the Taylor-Maccoll equation reduces to the directly solvable Legendre equation of first degree. Values of cone angle and pressure coefficient from this approximate treatment agree well with those obtained by the numerical integration. Pressure coefficients obtained from the Newtonian approximation fall 3 to 6% below the exact values. F. D. Bennett, USA

4637. Sen, H. K., Radiation broadening of a shock front (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **2**, 211–216.

Effect of radiative energy transfer on shock structure in ideal gas is computed, disregarding radiation energy density and pres-

sure. Effect is to diminish Prandtl number, and so to broaden the front, particularly for intense shocks. This paper extends previous work [*Phys. Rev.* **102**, no. 5, 1956]. S. Paterson, Scotland

4638. Sharaf, H. Ch., Influencing the position of the shock with high velocity (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 16, 63 pp., 1957.

4639. Franks, W. J., and Hall, J. G., Collision of plane shock waves with wire screens, *J. aero. Sci.* **24**, 12, 917–918 (Readers' Forum), Dec. 1957.

The purpose of this note is to mention shock-screen experiments done at University of Toronto Institute of Aerophysics in 1954–55 and to indicate a simple analysis used which accurately predicted the shock strengths measured. From authors' summary

Wave Motion in Fluids

(See Revs. 4558, 4559, 4565, 4582, 4585, 4586, 4602, 4777)

Turbulence, Boundary Layer, etc.

(See also Revs. 4338, 4583, 4589, 4692, 4693, 4722, 4725, 4726, 4728, 4729, 4739, 4749)

4640. Van Dyke, M. D., On viscous flow near a round leading edge (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3**, 318–325.

Paper treats incompressible viscous flow around a parabola ($y = 2(ax)^{\frac{1}{2}}$). The problem is of interest because it is a good approximation to the leading edge of a conventional subsonic airfoil and because the singularity at the leading edge of a flat plate is avoided.

The Navier-Stokes equations are written in parabolic coordinates and by a conventional expansion procedure a sequence of somewhat simpler equations is obtained. The paper deals mainly with the first equation, which is essentially the boundary-layer equation. Solutions are obtained as series in ascending and inverse powers of x/a. The series in ascending powers diverge for $x > a$, but by rearranging into a series in $x(x + a)^{-1}$ the convergence is greatly improved. The quantity $C_f R_x^{\frac{1}{2}}$ goes from 0 at the leading edge through a maximum at $x \sim 5a$ and then decreases to an asymptotic value. Using four terms gives 0.774 compared to the Blasius value of 0.664. The series in inverse powers involved logarithmic terms which Goldstein and Kaplun (unpublished) claim will improve the previous solutions [Alden, AMR **1** (1948), Rev. 1395].

A brief discussion is given of the correction due to the second equation and the Oseen linearization.

Reviewer believes this is an interesting contribution to the important but difficult problem of fitting the boundary-layer solution into the total flow field. W. Squire, USA

4641. Kostomarov, V. M., The laminar layer (film) in hydraulics (in Russian), *Gidrotekh. i melioratsiya*, no. 5, 29–37, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 1970.

At the outset of the article, written in connection with the work of E. A. Zamarin, author, without any foundation, compares the work of the Soviet school on the theory of turbulence (A. N. Kolmogorov and others) with the work of Western authors (Prandtl, Karman, Taylor and others), thus displaying elementary lack of information on the questions he is studying. Bringing forward the results of some known experiments, author notes the incompetent nature of Zamarin's assertion regarding the absence of adhesion of liquid to objects in the stream of liquid. In his conclusion author expresses the view that the semi-empirical theory of turbulence advanced by Karman-Prandtl should not, in general, be deleted from lectures and manuals, as Zamarin proposes to do, but should be explained, since "the engineer-hydrotechnician, a genuine innovator, in his practical activities will inevitably come across the propositions of the Karman-Prandtl theory, in one or another book or journal, for application in some cases of the movement of streams, the scientific form of which might win the confidence of the engineer, who has not the time to go sufficiently deeply into the minutae of the theoretical implications and estimate them at their actual significance (value)."

The appearance in a serious scientific journal of a discussion at such a low level can only evoke perplexity.

G. I. Barenblatt
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4642. Stivers, L. S., Jr., and Lippmann, G. W., Effects of fixing boundary-layer transition for an unswept-wing model and an evaluation of porous tunnel-wall interference for Mach numbers from 0.60 to 1.40, *NACA TN* 4228, 12 pp. + 14 figs., Apr. 1958.

4643. Jungclaus, G., On the stability of laminar flow with three-dimensional disturbances, Inst. Fluid Dynam. appl. Math., Univ. Maryland, AFOSR TN 57-577, 12 pp. + 1 fig., Sept. 1957.

H. B. Squire [*Proc. roy. Soc.* (*A*) **142**, 1933] has shown that two-dimensional disturbances are more dangerous for two-dimensional flows than three-dimensional disturbances, i.e., for a given Reynolds number there is always a two-dimensional disturbance which will be amplified more than any three-dimensional disturbance. In an extension of this investigation A. M. Kuethe [AMR **5**, (1952), Rev. 2121] has shown that in the case of yawed cylinder the three-dimensional waves in certain cases may be more unstable than the two-dimensional waves.

Present report gives two conclusions from the papers of Squire and Kuethe: (a) For two-dimensional flow, standing three-dimensional waves are possible in the case of artificial excitation of turbulence or in the case of a channel having finite width and porous sidewalls for sucking. (b) For the yawed plate it has been found that of all three-dimensional disturbances the disturbance waves in direction of the undisturbed flow are amplified most. K. Gersten, Germany

4644. Butler, S. F. J., Current tests on laminar-boundary-layer control by suction through perforations, *Aero. Res. Counc. Lond. Rep. Mem.* 3040, 13 pp. + 1 table + 11 figs., 1957.

This note describes current experiments on laminar-boundary-layer control by suction through perforations. No attempt was made to obtain full-chord laminar flow, as this had been shown previously to be a natural consequence of applying a suitable suction distribution, providing turbulent wedges did not result from oversuction. In the present tests, the main aim therefore was to determine the flow rates at which such wedges appeared for different arrangements of perforations. In order to simplify the test procedure, most of the results were obtained using one or more closely spaced rows of perforations at a single chordwise station on an otherwise plain wing. A method is given, supported by some experimental evidence, for predicting the perforation spacing which would be required in a full-chord application from the results thus obtained at a single chordwise station.

With all the configurations tested, a limiting suction rate was found above which turbulent wedges appeared, causing premature transition. This limit exhibited an adverse Reynolds number effect and also made it essential to use a uniform backing to obtain a satisfactory performance. It is suggested that flow curvature under three-dimensional conditions may further restrict the suction rates which could be used.

Because of the adverse Reynolds number effect, the present tests needed to be extended to cover flight values of U_o/ν. A short program of tests will cover the practicable diameter range

with different geometrical configurations to provide two-dimensional data. If these tests are successful, the logical next step would be for an aircraft designer to choose a configuration based on the wind-tunnel results and prove it under flight conditions.

From author's summary

4645. Rotta, J., An experimental contribution to the transition from laminar to turbulent flow in a pipe, 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **3,** 350–359.

4646. Cramer, K. R., On laminar separation bubbles, *J. aero. Sci.* **25,** 2, 143–144 (Readers' Forum), Feb. 1958.

4647. Tetervin, N., A discussion of cone and flat-plate Reynolds numbers for equal ratios of the laminar shear to the shear caused by small velocity fluctuation in a laminar boundary layer, *NACA TN* 4078, 21 pp., + 4 figs., Aug. 1957.

Paper obtains an approximate relation between the Reynolds number on a cone and that on a flat plate for "equal closeness to transition." Here, "closeness to transition" is measured by the ratio of the maximum value of the disturbance shear to the laminar shear in the boundary layer. The specific relation between the cone and plate Reynolds number for "equal closeness" is obtained by equating this ratio for the cone with the ratio for the flat plate. Calculations of the disturbance shear are based on results from incompressible linear stability theory. The analysis indicates that the ratio of the cone to plate Reynolds number for transition varies from 3, when transition occurs at the minimum critical Reynolds number, to unity, when transition occurs at a large multiple of the critical Reynolds number. Existing experimental data are too scanty to support conclusion, although reviewer believes it to be fundamentally correct.

R. F. Probstein, USA

4648. Dorfman, L. A., Turbulent boundary layer on a rotating disk (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 138–142, 1957 (translated from Russian by M. D. Friedman, 67 Reservoir St., Needham Heights, Mass., D-127, 6 pp.).

Rigorous argument aims to supplement the present theory on properties of boundary layer with rotating disk. Theories of Prof. Karman, Goldstein, and the more recent one of Schlichting are used for initial exploration and correlation with some experimental results. Using essentially the velocity profile for derivation of boundary-layer properties, author proceeds to show what appears to be final expression for the resistance moment on both sides of the rotating disk and for the boundary-layer thickness. Exponent evolved in the expression of resistance moment coefficient (function of Reynolds number) equals to that in drag formula for smooth plate. A number of pertinent references are included. Results in this brief paper are applicable for computation of friction of turbine and related elements. C. R. Bell, USA

4649. Black, T. J., A simplified form of the auxiliary equation for use in the calculation of turbulent boundary layers, *Aero. Res. Counc. Lond. curr. Pap.* 370, 14 pp. + 7 figs., 1958.

Paper gives calculation of the growth of the form parameter H in turbulent boundary layer with adverse pressure gradients. The auxiliary equation used has been derived by extending an analysis by Spence [AMR **9** (1956), Rev. 1531] and introducing the findings of Ross [*J. aero. Sci.* **21,** p. 355, 1954] and of Ludwieg and Tillmann [*NACA TM* 1285]. Comparison is made with former methods and experimental results. I. Flugge-Lotz, USA

4650. Irmay, S., On three layers in turbulent flow, *Bull. Res. Counc. Israel* **6C,** 1, 71–72 (Letters to the editor), Nov. 1957.

4651. Munk, M. M., Turbulence theory in the light of the circular pipe flow, Catholic Univ. of Amer., 33 pp., May 1957.

4652. Helmbold, H. B., Universal wall distance functions for flow with equilibrium turbulence (in German), *Forsch. Geb. Ing.-Wes.* **23,** 6, 210–213, 1957.

A survey of the hitherto obtained experimental results led to some formulas of universal validity in which the turbulent fluctuation quantities and the wall distance are related for certain turbulent flows through tubes, channels, and diffusers as well as for the flat plate, thus covering equilibrium turbulence in flows without or with pressure gradient in flow direction. These universal laws do not apply to regions near free boundaries of the flow where intermittence occurs. From author's summary

4653. Rogers, E. W. E., and Davis, Miss B. M., A note on turbulent boundary-layer allowances in supersonic nozzle design, *Aero. Res. Counc. Lond., curr. Pap.* 333, 14 pp. + 11 figs., 1957.

Some of the theoretical methods for computing the growth of turbulent boundary layers along both the curved and straight walls of a rectangular supersonic wind tunnel are discussed and the estimated values compared with experiment. Approximate formulas, which may be useful in the initial stages of nozzle design, are suggested for the over-all boundary-layer growth along the curved nozzle and flat wall. From authors' summary

4654. Rouse, H., Siao, T. T., and Nagaratnam, S., Turbulence characteristics of the hydraulic jump, *Proc. Amer. Soc. civ. Engrs.* **84,** HY 1, (*J. Hydr. Div.*), Pap. 1528, 31 pp., Feb. 1958.

In order to overcome well-known experimental difficulties, the turbulence characteristics of the hydraulic jump have been determined by hot-wire anemometer in an air model of the jump for Froude numbers of 2, 4, and 6. The boundary of the jump has been simulated by the solid walls of an air-duct, conveniently placed and accurately adjusted so as to obtain a satisfactory agreement between the mean flow characteristics of model and prototype.

Reference has been made to the momentum and energy equations written for tri-dimensional flow, the elements of the mean flow being separated from those of the fluctuating flow in the usual Reynolds form. By means of a double Pitot tube and of the hot-wire anemometer the patterns of the mean and fluctuating motion have been analyzed and the values of the corresponding terms of the aforementioned equations evaluated.

Some interesting conclusions, both quantitative and qualitative, have been reached concerning the generation and convection of turbulence in the jump and the transformation and dissipation of energy. P. L. Romita, Italy

4655. Wise, B., and Schultz, D. L., Turbulence measurements in supersonic flow with the hot-wire anemometer, *Aero. Res. Counc. Lond. curr. Pap.* 366, 13 pp. + 19 figs., 1957.

Hot-wire anemometer equipment developed by the author is described and sample measurements in a supersonic wind tunnel at $M = 1.6$ are briefly discussed. For low noise level, transformer coupling was used between wire and amplifier. Time constant calibration was executed by injection of modulated R. F. power (5.5 Mc carrier). The free-stream turbulence in the tunnel was analyzed and the fluctuations were decomposed into stagnation temperature and mass flow fluctuations.

L. S. G. Kovasznay, USA

4656. Yaryshev, N. A., Theory of thermal lag of hot-wire anemometers in a flow of gas with pulsating velocity (in Russian), *Sb. rabot stud. naucb. o-va Leningr. in-ta tochnoimekhan-i optiki* no. 13, 71–78, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2118.

From the equation of thermal equilibrium an equation is deduced for the elevation of the temperature of the wire of the hot wire anemometer above the temperature of the oncoming medium in relation to time with the given mass and dimensions of the wire, current flowing along the wire, coefficient of heat emission. The equation is solved with the retention of terms of the first order of

smallness. An expression is obtained for "the constant time" of the hot wire anemometer, which (in other denotations) agrees precisely with that obtained earlier by Yu. G. Zakharov [Tr. Ts AG 1, p. 599, 1946]. A. S. Danilov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 4596, 4603, 4611, 4613, 4622, 4625, 4626, 4627, 4642, 4680, 4682, 4683, 4685)

4657. Vallee, D., Effect of side-slip on a delta wing (in French), *Rech. aéro.* no. 57, 3–6, Mar.–Apr. 1957.

The aerodynamic derivatives of a delta wing in side-slip have been calculated for supersonic flow, using the conical flow method. The position of the aerodynamic center is found to be independent of the angle of side-slip. Furthermore, the drag coefficient and the rolling moment coefficient are independent of the Mach number for a given geometry of the wing.

H. Schlichting, Germany

4658. Rettie, I. H., An investigation of the velocity distribution around the nose of the aerofoil with a flap, *Aero. Res. Counc. Rep. Mem.* 3027, 10 pp. + 15 figs., 1957.

The velocity distribution around the nose of an NACA 0015-64 airfoil was found by experiment and that around the nose of a Piercy 15/40 airfoil by calculation for various angles of incidence and flap deflection. It was established that at all incidences this velocity distribution is a function of the position of the stagnation point, irrespective of the flap deflection.

This result is shown to be true generally, and it is suggested that use might be made of it in the design of a lift-coefficient meter, which could also be used to give warning of a stall.

From author's summary by H. Mirels, USA

4659. Patraulea, N. N., Two extensions of jet-flapped wing problem (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2**, 2, 1957.

Paper discusses problems of jet-flapped airfoil in presence of given singularities and finite jet-flapped wing.

Both solutions are based upon a method previously given by the author when determining the flow around an isolated jet-flapped profile ["Contribution théorique à l'étude des profils à volets fluides," Actes du IX e Congrès International de Mécanique Appliquée, Université de Bruxelles, 1957, vol. I].

Staff, Revue de Mécanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4660. Patraulea, N. N., Dumitrescu, L., Popescu, C., Caprita, D., and Gab, H., Experimental investigations on blown airfoils (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2**, 2, 1957.

Paper presents the results of some tests made with a blown airfoil on which supercirculation is created by a series of jets emerging from its upper surface. This arrangement increases the lift by producing a sink effect on the upper surface of airfoil, followed by a jet-flap effect downward at the trailing edge. For equal jet coefficients, results show a gain of lift over simple jet-flapped airfoils.

Also included are generalized deductions of the jet coefficient and of an energy coefficient with considerable practical meaning.

Staff, Revue de Mécanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4661. Attinello, J. S., The jet wing, *Aero. Engng. Rev.* **16**, 8, 52–55, Aug. 1957.

4662. Kuchemann, D., and Maskell, E. C., Some remarks on the jet wing and VTOL aircraft, *Aero. Engng. Rev.* **16**, 8, 56–57, Aug. 1957.

4663. McArdle, J. G., Internal characteristics and performance of several jet deflectors at primary-nozzle pressure ratios up to 3.0, *NACA TN* 4264, 39 pp. + 2 tables + 49 figs., June 1958.

Several model jet deflectors (devices which change the direction of resultant jet thrust) were tested in quiescent air. The deflectors (swiveled nozzles, auxiliary nozzles, and mechanical deflectors) were designed to be adaptable to conventional turbojet exhaust systems and produced side force as high as 43% of the undeflected jet thrust. Analytical expressions relating the performance of each type of deflector with significant design variables are also presented. From author's summary

4664. von Glahn, U. H., Use of the Coanda effect for obtaining jet deflection and lift with a single flat-plate deflection surface, *NACA TN* 4272, 23 pp. + 1 table + 17 figs., June 1958.

Performance characteristics similar to those for a flap immersed in an airstream were obtained in quiescent air for nozzle-deflection-plate configurations using the Coanda effect for achieving jet deflection and vertical lift. With a simple flat-plate deflection surface the optimum ratio of lift to undeflected thrust follows a sine function with plate deflection angle. Because of jet detachment from the deflection plate, the configurations studied were limited to specific deflection angles depending on nozzle height. An empirical relation was derived for predicting the required plate length in terms of nozzle height for achieving optimum performance at a given deflection-plate angle and pressure ratio.

From author's summary

4665. Seiff, A., A new method for computing drag coefficients from ballistic range data *J. aero. Sci.* **25**, 2, 133–134 (Readers' Forum), Feb. 1958.

4666. Report of the Definitions Panel on definitions to be used in the description and analysis of drag, *Aero. Res. Counc. Lond. curr. Pap.* 369, 8 pp. + 2 figs., 1958.

Terms used in the description and analysis of the external drag of a body (with or without internal flow) are considered, and definitions suggested for the various components of the drag. Care has been taken to insure that the proposed terms are consistent with those used in the Panel's report on thrust.

From summary

4667. DeYoung, J., Rule of thumb equation for predicting lifting-surface-theory values of lift, *J. aero. Sci.* **24**, 8, p. 629 (Readers' Forum), Aug. 1957.

4668. Kettle, D. J., Ground performance at take-off and landing, *Aircr. Engng.* **30**, 347, 2–4, Jan. 1958.

A simple chart is presented for the rapid evaluation of either unstick or landing roll distance. The method is incomplete in that it does not deal with the airborne phase of take-off and landing maneuvres; it is necessary to estimate this part separately. The chart is strictly applicable only when wing incidence remains constant for the whole of the ground run. In the case of the landing roll, some uncertainty exists as to the precise value of μ, the braking coefficient of friction. An attempt is made to relate an equivalent value of μ to touchdown speed for the standard wet and dry runway as adopted by I.C.A.O., assuming that automatic brakes are fitted, with a maximum braking force equal to 0.35 of the landing weight. From author's summary

4669. Buckingham, W. R., A theoretical analysis of the airborne path during take-off, *Aircr. Engng.*, **30,** 347, 5–8, Jan. 1958.

The solution of the problem of estimating the take-off distance to a height of 50 feet has to a certain extent been limited by the absence of a theoretical analysis of the airborne part of the take-off maneuver.

The three main physical quantities associated with the motion immediately after an aircraft leaves the ground are aircraft speed, the angle the flight path makes with the horizontal, and the lift coefficient increment. This latter quantity is the lift coefficient in excess of that required for level flight at the unstick speed, and is produced when the pilot pulls the stick quickly back at take-off.

A linear theoretical analysis is obtained by assuming that variations of the physical quantities already mentioned are small enough for squares and higher powers of such variations to be neglected in comparison with the variations themselves. The results of the analysis depend on the solutions of a pair of ordinary simultaneous linear differential equations with constant coefficients.

If the aircraft speed never falls below the unstick speed, the limiting values of the lift coefficient increment which define the safe range of take-offs can be determined. By considering the mean value of the lift coefficient increment over the safe range of take-offs it is possible to define a mean safe take-off, and, for such a take-off, the mean safe airborne distance from the unstick point to a height of 50 feet can be estimated.

The application of the theory as a means of estimating the take-off performance of a bomber aircraft is given as an example.

From author's summary

4670. Kuhn, R. E., Take-off and landing distance and power requirements of propeller-driven STOL airplanes, *Aero. Engng. Rev.* **16,** 11, 38–42, Nov. 1957.

4671. Davis, R. A., The response of a bisymmetric aircraft to small combined pitch, yaw, and roll control actions, *J. aero. Sci.* **24,** 12, 905–910, Dec. 1957.

Linearized equations of motion using body axes are derived for a rolling missile with wings and tail surfaces arranged bisymmetrically. Due to roll, a downwash-lag effect arises which depends on the vectorial rate of change of the angle of attack, i.e. cross-coupled velocity terms must be included. With the downwash roll angle kept small (less than 0.1), the downwash lag terms can be linearized. Stability criteria are then derived which are independent of the rolling of the reference axes. Complete solutions are given for a stepped pitch/yaw control at constant roll rate. For variable roll rate, a solution is given for a simplified system which neglects the Magnus effect.

H. P. Liepman, USA

4672. Aiken, W. S., Jr., Analysis of horizontal-tail loads in pitching maneuvers on a flexible swept-wing jet bomber, *NACA TN* 4191, 36 pp. + 7 tables + 15 figs., Dec. 1957.

Wing-fuselage aerodynamic center position, pitching-moment coefficient at zero lift, and effective airplane moment of inertia are derived from flight measurements of the airplane motions and the horizontal tail loads for a medium bomber at Mach numbers 0.4–0.8 at altitudes 20,000–35,000 ft. Two methods are used (one based on direct tail-load measurements, the other on elevator angle measurements) to obtain the above parameters from the pitching moment equation, using a method of least squares. Full details of these methods are given.

Results are compared with wind-tunnel measurements, large discrepancies being noticed in some cases (especially at low Mach numbers). Factors contributing to errors are discussed, but no complete explanation is given.

A. W. Babister, Scotland

4673. Seaberg, E. C., Three-degree-of-freedom evaluation of the longitudinal transfer functions of a supersonic canard missile configuration, including changes in forward speed, *NACA TN* 4192, 12 pp. + 3 tables + 5 figs., Dec. 1957.

Subject note presents cumulative evaluation of missile (130 in. long and 8 in. diam) with canard fins span of 17.7 in. and wing span of 37 in. Transfer function characteristic equations and static sensitivities are shown for $M = 1.2$ and $M = 1.6$ (both at S.L.) with three angles of attack (0°, 4° and 10°), with and without incorporating velocity derivatives (coefficients of lift, drag and pitching moment). Plots of velocity derivatives are presented for $M = 0.8$ to $M = 1.8$ with angles of attack between 0° and 10°. Finally, plots of longitudinal frequency responses (with and without effects of velocity derivatives) for three values of trim (0°, 4° and 10°) are shown at $M = 1.6$ (at S.L.).

Comparison of such data disclosed the variations with angle of attack, mainly in low frequency regions (below 10 rad/sec) and with variations depending upon use or omission of velocity derivatives. It was concluded that incorporation of these derivatives is significant in the solution of longitudinal transfer functions.

Consideration of automatic controls is included and a list of pertinent references is among the good features of the treatment. It is a competent contribution to the literature needed for understanding of problems associated with prediction of missile stability.

C. R. Bell, USA

4674. Rodden, W. P., Extension of "An aeroelastic parameter for estimation of the effects of flexibility on the lateral stability and control of aircraft," *J. aero. Sci.* **24,** 8, 624–625 (Readers' Forum), Aug. 1957.

4675. Hacker, T., On a problem of partial stability of aircraft (in Russian), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 2, 1957.

Classical stability criteria, such as the Routh-Hurwitz criterion, do not give indications concerning the separate behavior of kinematic parameters. If one of the parameters grows larger, these criteria indicate instability even in the case when the behavior of this parameter is of no importance to the problem.

With this idea in mind, author presents a procedure to find conditions which should insure the damping of the deviation of the incidence angle, or that of the rate of pitch. Expressions are given which relate the initial value of the disturbance to the time interval within which a certain previously given damping velocity is insured for the discussed kinematic parameters.

Staff, Revue de Mêcanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4676. Czaykowski, T., Loading conditions of tailed aircraft in longitudinal maneuvres, *Aero. Res. Counc. Lond. Rep. Mem.* 3001, 59 pp., 1956.

An analysis of aircraft response and loading conditions in symmetrical maneuvres is presented with a particular recognition of the designer's needs.

The analysis is based on the theory of aircraft response to elevator-induced longitudinal maneuvres. Basic response functions have been derived for the chosen, exponential type of elevator motion, and, from these, general expressions have been obtained for various derived response quantities, such as tailplane loads, elevator hinge moments, normal accelerations at the tail, etc.

A computational method which reduces the calculations to a routine allows the evaluation of the complete time histories of response quantities or, alternatively, their significant maxima.

The simplifying assumptions underlying the analysis are critically reviewed and possible limitations of the method are discussed.

From author's summary

4677. Sponder, E., A remark on stability equations, *J. aero. Sci.* **25,** 2, 129–130 (Readers' Forum), Feb. 1958.

4678. Gray, V. H., and von Glahn, U. H., Aerodynamic effects caused by icing of an unswept NACA 65A004 airfoil, *NACA TN* 4155, 19 pp. + 2 tables + 12 figs., Feb. 1958.

4679. Taliev, V. N., Aerodynamic characteristics of new designs of hanging lamps (in Russian), *Naucb. soobsbcb. Tsentr. n.-i- in-ta from sooruzb.* no. 24, 38 pp., 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 415.

Results are given of systematic investigations of new designs for hanging lamps, erected on the roofs of buildings. Investigations covered not only the determination of the coefficients of local resistance by the skylights but also their liability to be blown in. The first set of experiments were carried out in a special aerodynamical set-up, and the second in a wind tunnel. In both cases the experiments were performed on models of the skylights, of the experimental apparatus, and of the test methods. Experimental results are shown in tables of the coefficients of local resistances and of coefficients of useful work with skylights of different designs in diagrams of distribution of speeds (of air) in the areas of these skylights. Based on the investigations made, types of skylights not liable to be blown in are indicated and recommendations are put forward for their adoption.

I. E. Idel'chik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 4387, 4388, 4674)

4680. Collar, A. R., On the stability of accelerated motion: Some thoughts on linear differential equations with variable coefficients, *Aero. Quart.* **8,** 4, 309–330, Nov. 1957.

The treatment of the problem of the stability of aeronautical systems is more complex when the flight speed varies with time. Then the set of linear differential equations has variable coefficients. In this very interesting paper author treats these problems, suggesting some approaches to the discussion of stability during acceleration. Inverse methods of approach are suggested also.

The paper has three parts. The first part deals with some necessary extensions of ideas on stability. In the second part is treated the single second-order equation with variable coefficients. As an example, the equations of motion of a fluttering system are discussed. It is shown that the effects of acceleration depend on a dimensionless acceleration number. The third part deals with the stability problem of accelerated systems of aerodynamic type. A set of matrix equations of motion of a rigid body subjected to air forces is discussed. One numerical example concerning evaluation of the stability is demonstrated. Some comments on a set of three second-order differential equations are given. The inverse methods illustrated in this part throw light on tendencies and direct attention to important parameters.

D. Raskovic, Yugoslavia

4681. Martin, D. J., Summary of flutter experiences as a guide to the preliminary design of lifting surfaces on missiles, *NACA TN* 4197, 17 pp. + 8 figs., Feb. 1958.

Presented is a limited review of some experiences in flight testing of missiles and of wing flutter investigations that may be of interest in missile design. Several types of flutter of concern in missile studies are briefly described. Crude criteria are presented for two of the most common types of flutter to permit a rapid estimate to be made of the probability of the occurrence of flutter. Many of the details of the flutter problem have been omitted, and only the broader elements have been retained so as to give the designer an over-all view of the subject.

From author's summary

4682. Molyneux, W. G., and Ruddlesden, F., Derivative measurements and flutter tests on a rectangular wing with a full span control surface, oscillating in modes of wing roll and aileron rotation, *Aero. Res. Counc. Lond. Rep. Mem.* 3010, 10 pp. + 2 tables + 16 figs., 1957.

Details are given of tests to measure the aerodynamic coefficients for a rectangular wing with a fullspan aileron oscillating in modes of wing roll and aileron rotation. A new technique was used in which aileron rotation was geared to wing roll so that oscillation occurred in both degrees of freedom simultaneously.

The measured coefficients are compared with those derived from two-dimensional theory, and with coefficients estimated by an empirical method. The agreement with theory is poor but the estimated coefficients agree well with those measured.

Flutter calculations for the system were made, using both measured and theoretical derivatives, and the results are compared with flutter test results. The calculated flutter speed using measured derivatives agrees closely with that measured, whereas using theoretical derivatives the agreement is poor.

From authors' summary

4683. Molyneux, W. G., and Hall, H., The aerodynamic effects of aspect ratio and sweepback on wing flutter, *Aero. Res. Counc. Rep. Mem.* 3011, 7 pp. + 6 tables + 7 figs., 1957.

The method of Molyneux and Chapple [*British Aero. Res. Counc. Rep. Mem.* 2942] is extended to rigid swept wings. It is shown that fairly good estimates of wing flutter speeds and frequencies can be obtained using two-dimensional aerodynamic theory together with simple factors for aspect ratio and sweepback effects. These factors are based on tests on rigid wings (free to pitch and roll) at low speeds, but they may also be of use in flutter prediction for flexible swept wings. The effect of taper (and inverse taper) is also considered.

A. W. Babister, Scotland

4684. Molyneux, W. G., A geared flywheel balance arrangement for the prevention of control surface flutter, *Aero. Res. Counc. Lond. curr. Pap.* 365, 9 pp. + 1 table + 6 figs., 1957.

Some geared mass balance systems are described that are effective in eliminating inertial couplings between modes of the main surface and the control surface. These arrangements are shown to have an advantage over the conventional arrangement for preventing flutter involving main surface torsion and control rotation, particularly where there is a near frequency coincidence between the modes.

From author's summary

4685. Cole, H. A., Jr., Brown, S. C., and Holleman, E. C., Experimental and predicted longitudinal and lateral-directional response characteristics of a large flexible 35° swept-wing airplane at an altitude of 35,000 feet, *NACA Rep.* 1330, 39 pp., 1957.

Airframe dynamic response to control surface inputs was measured on a B-47A jet bomber and compared with predicted response characteristics. The test altitude was 35,000 ft; the Mach number range was 0.6 to 0.85. Longitudinal time histories (at several c.g.'s) and lateral-directional time histories were measured in response to pilot-applied pulses. The results were converted to frequency responses by use of the Fourier integral. The range of frequencies covered included several structural natural frequencies. At the lower frequencies, transfer function coefficients were determined, and also aerodynamic derivatives in some cases, for comparison with rigid body and first-order flexible body predictions.

The results were quite good and indicate that the prediction method is satisfactory up to about half the lowest structural natural frequency. The methods of analysis and prediction presented seem workable and straightforward. The program as described appears well rounded and thorough in both prediction and measurement. Since the tests were performed at a single altitude, how-

ever, there are no independent checks of the effects of Mach number and dynamic pressure. J. N. Ball, USA

Propellers, Fans, Turbines, Pumps, etc.

(See Revs. 4388, 4426, 4524, 4580, 4602, 4768)

Flow and Flight Test Techniques

(See also Revs. 4592, 4644, 4654, 4655, 4682, 4793)

4686. Hunsinger, W., The status of electric measurement techniques, especially as applied to measurement of non-electric quantities (in German), *Elektrotech. u. Maschinenb.* **74**, 3, 49–57, Feb. 1957.

For industrial measurements three types of electric instruments are mainly used: moving-coil, moving-core, and electrodynamometer instruments. Recent improvements in these were made possible by new materials having greatly increased magnetic and dielectric properties and constancy, and by use of ceramics for nonmagnetic components. Extensive use of electric instruments for process control led to the establishment of central instrument stations and switchboards with a large number of indicating and control instruments. For saving space and improving the visibility the quadrant-type and the profile- (edge-) type instrument dials have been widely adopted. Suspension of moving elements on spring-tensioned bands, instead of conus-and-cup bearings, improves robustness against dynamic shocks. Advantages of electric instruments are easy transfer of indicating current from the measuring point to the central instrument station, relatively easy construction of pickups for the transformation of the measured quantity into an electrical voltage or current, small energy needed for feeding the indicating galvanometer, possibility for transforming several data into a combined indication (e.g., sums, differences, products, quotients), and possibility of using the electric quantity for control.

Pickups having importance in process industries are described: (1) for temperature measurement (thermocouples and resistance thermometers); for strain and pressure (by resistance by stressed wires or by carbon pile, piezoelectricity, inductive and capacitive effects); for rotative speed (e.g., by condenser charged by an interrupter driven by rotating shaft); for flow measurement (electronic current balance); and for continuous gas analysis based on physical (not chemical) properties of the gases measured (e.g. heat conductivity), such as oxygen, hydrogen, carbon dioxide. Some gas analyzers are based on the magnetic properties, and on the infrared absorption properties, of the gases investigated.

K. J. DeJuhasz, Germany

4687. Pavelescu, D., and Pantelimon, T., Magnetic tape recording of mechanical quantities with slow variations (in French), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2**, 2, 1957.

Authors deal with a new research method consisting of recording the variations of mechanical quantities on a magnetic tape. Method also allows for recording of other phenomena which may be transposed into variable electrical quantities. Results obtained and practical applications are discussed.

Staff, Revue de Mécanique Appliquée
Acad. Repub. Pop. Romane, Rumania

4688. Dombrowski, N., Photographic methods of analysis in chemical engineering research, *Chem. Engr., Lond.* no. 128, 6 pp., 17 figs., Dec. 1956.

Author describes some applications of photography to chemical engineering research. Emphasis is on techniques, listing four basic methods of illumination: diffuse frontal lighting; specular reflection; diffuse rear lighting; shadow lighting. Advantages of each for various research purposes are described. Picture examples are given of: breakup of a liquid sheet to form drops; schlieren photograph of flame front; streak photograph of ball trajectories in ball mill; streak photograph of moving aerosol particles; air movement around conical spray sheet; double-exposure photograph of spray sheet in the process of breaking up.

K. J. DeJuhasz, Germany

4689. Broer, L. J. F., Hoogendoorn, C. J., and Kortleven, A., Some investigations on low-speed anemometry, *Appl. sci. Res. (A)* **7**, 1, 1–13, 1958.

Authors investigate the suitability of thermistors (semiconductors) for low-speed anemometry. The instrument used consisted of a semiconducting material contained in a glass tube of 2-mm outer diameter and 10-mm length. The thermistor was heated electrically by means of a nichrome wire wound around the glass tube. When the heating current is constant, the thermistor resistance—which is measured—is a function of the velocity across the instrument and of the ambient temperature. It appears that the laws for the heat transfer from cylinders by free and by forced convection hold. The thermistor anemometer shows no essential improvement compared with the hot-wire anemometer.

Next the heat transfer from a tungsten wire of 5-mm length, 4.0–7.2 micron thick, was investigated at low Re. The results are given as $Nu = f(Re)$ and compare favorably with those obtained by others and with correlation formulas.

In the last section a new method for computing the heat transfer from fine wires in the Oseen range is presented.

B. G. v. d. Hegge Zijnen, Holland

4690. Autenrieth, K., and Voigt, H., The application of the piezoelectric technique of measurement to record the pressure-time history in high-tension output switches (in German), *Elektrotechn. Z. (A)* **78**, 16, 572–577, 1957.

Since the introduction of high-voltage electric power the importance of investigating the pressure variation in high-power switches has been recognized; knowledge of the pressure influences the design and materials of the interupter. Work of previous investigators is surveyed. Capacitive and piezoelectric pickups are compared; requirements for use on high-power switches are discussed, namely: to be unaffected by electrical and magnetic influences, and by mechanical shocks; temperature influence is not important because the pressure shocks last only a few centiseconds; the natural frequency of vibration of the pickup should be far above the pressure fluctuation frequency. Several piezoelectric (quartz) pickups developed for this service are described and illustrated; one pickup has 7.7, the other 59, kilocycles frequency; output at end of a 15-ft cable is about 0.1 Volt/atm. Amplifier to be used with the pickup is described and its electric data given. Dynamic calibration of pickup is described, and setup is illustrated. Error sources are discussed; the cable requires high dielectric insulation, but the generation of frictional electricity on the insulation must be prevented, which can be achieved by a layer of low conductivity on the outer surface whereby any generated static electricity can be drained off. Mechanical shocks can produce false pressure indications by the pickup. A testing setup, with insulated table and a small a-c generator driven through an insulated shaft, is described and illustrated; oscillograms are shown giving simultaneous values of switching pin motion, voltage, current, and pressure.

K. J. DeJuhasz, Germany

4691. Strasberg, M., and Cooper, R. D., Measurements of the fluctuating pressure and velocity in the wake behind a cylinder (in English), 9th Congrès intern. Mêcan. appl., 1957; **2**, 384–393.

Cylinder was mounted with axis transverse to air flow in wind tunnel. Diameters of one and four inches were used in spanning 7000 to 120,000 in Reynolds number. Probe microphone and hot

wire were simultaneously used to obtain rms values of fluctuating parts of pressure and velocity. Both parts consist of discrete-frequency components associated with vortex shedding plus similar continuous spectra whose Strouhal number fD/U_0 ranges from 0.01 to 20. Traverses through wake show amplitude of shedding frequency falls rapidly both laterally and downstream. Twin-beam oscillograms of pressure and velocity are presented to show correlation between them is best near the cylinder.

D. Moseley, USA

4692. Monaghan, R. J., The use of pitot-tubes in the measurement of laminar boundary layers in supersonic flow, *Aero. Res. Counc. Lond. Rep. Mem.* 3056, 14 pp. + 2 tables + 14 figs., 1957.

Consideration of experimental results obtained with relatively large pitot-tubes in relatively thin laminar boundary layers on cones and flat plates in supersonic wind tunnels and then analyzed using standard pitot equations shows that the most noticeable distortion of the velocity profile is the appearance of a peak near the outer edge of the boundary layer. The displacement of the main body of the profile, familiar in incompressible-flow tests, may be small in supersonic flow and difficult to detect when making measurements with small-diameter pitot-tubes.

Displacement and momentum thicknesses (δ^* and θ) calculated from pitot traverses will be in error because of this distortion and displacement. The simple correction factor obtained by Davies is shown to correlate results obtained by Blue and Low and indicates that if the ratio of tube diameter to boundary-layer thickness is less than 0.2 then measured values of δ^* and θ may be less than 4% above their true values.

Additional profile distortion may occur if flattened pitot-tubes are used to measure boundary layers on slender bodies of revolution and Appendix II describes the method of manufacture of tapered quartz tips of circular cross section, which have a better response rate than flattened tubes of the same internal height.

From author's summary

4693. Dutton, R. A., The accuracy of measurement of turbulent skin friction by means of surface pitot-tubes and the distribution of skin friction on a flat plate, *Aero. Res. Counc. Lond. Rep. Mem.* 3058, 12 pp. + 10 figs., 1957.

An experimental study has been made of two-dimensional turbulent boundary-layer flow with zero pressure gradient. The investigation was made to determine the accuracy of a method proposed by Preston for measuring the local turbulent skin friction. The general momentum equation was used in conjunction with measurements of skin friction by Preston's method, to obtain increments in momentum thickness which could be compared with the measured values. The experiments were made on a smooth flat plate, 6 ft long, which spanned the working-section of a return-circuit wind tunnel. Transition was promoted by trip wires and glass-paper strips. A constant Reynolds number of 3.9×10^5 per foot was maintained throughout the experiments.

The results, together with certain basic arguments, indicate that Preston's method will give the correct skin friction. For the range of Reynolds numbers covered in the experiments ($1500 < R_\theta < 4000$) the skin-friction coefficients obtained for different values of R_θ (the Reynolds number based on momentum thickness) were approximately 10 per cent and 6 per cent less than the corresponding Prandtl-Schlichting and Schoenherr values, respectively.

From author's summary

4694. Hubner, E., The measurement of small pressures varying with time (in German), *Forsch. Geb. Ing.-Wes.* **20**, 1, 20–31, 1954.

When measuring pressures variable with time the pressure-measuring elements (pickups) and the connecting passages represent coupled mechanical vibrating systems. By applying to mechanical vibration problems calculating methods similar to those used for alternating-current problems it is possible to calculate the frequency-dependent contaminations of the measuring process, and in particular to determine that limiting frequency at which the contaminating error attains a predetermined permissible value. Various types of pickups (resistance type, photoelectric, inductive, condenser type) are surveyed. The dynamic relationships of the pickup at periodic and nonperiodic pressure variations are discussed, and the magnitude of errors and the limiting frequency, also the optimal damping, are calculated. The influence of the connecting passage is calculated for periodic and nonperiodic pressure fluctuations by means of setting up equivalent electric circuits and applying to them calculating techniques used in alternating-current computations. A number of numerical examples are worked out. It is pointed out, however, that the calculating methods are based on the assumption of lumped masses and lumped elasticities, while these exist actually in distributed forms. Furthermore, at high pressures the assumption of the linear law of propagation of an acoustic wave is no longer valid, and therefore the calculated results should be regarded as approximate estimates rather than accurate values.

K. J. DeJuhasz, Germany

4695. Vereshchagin, L. F., Likhter, A. I., and Ivanov, V. I., Obtaining very high pressures in apparatus with a taper plunger (in Russian), *Zh. tekh. Fiz.* **26**, 4, 874–877, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 423.

Paper describes construction of apparatus for obtaining extremely high pressures by means of a taper plunger (working in a cylinder) in which the use of packing (layers, gaskets) rings are not essential. The apparatus consists of a chilled steel die, a cone made from soft steel with an inner opening into which is fitted the body of the electrode. The cone is inserted in the opening of the die, while on the body of the electrode a mechanism is fixed for transmitting the force, developed by the press on the cone. On the bottom of the opening in the die is poured a liquid of low compressibility such as glycerine. The lower part of the opening is filled with lead (molten) and above it petroleum ether. After assembly, the apparatus is placed under a press (hydraulic) and subjected to compression. Pressure inside the cone is then measured by means of a manganese-nickel-copper alloy manometer which is soldered to the electrode. A theoretical and an experimental investigation is carried out on the work (efficiency) of the apparatus. Pressures up to 14,000 Kg/cm^2 were obtained. The apparatus might be utilized to determine the compressibility of liquid and solid bodies, by comparing the results of tests for substances with known and unknown compressibility.

N. N. Shirokov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4696. Binnie, A. M., and Phillips, O. M., The mean velocity of slightly bouyant and heavy particles in turbulent flow in a pipe, *J. Fluid Mech.* **4**, 1, 87–96, May 1958.

A large number of 0.2-in. diameter spheres were successively injected into a horizontal 2-in. diameter pipe conveying water at constant mean velocity. The transit times of the spheres were accurately measured between stations which were spaced 16.40 ft, 33.42 ft, and 49.82 ft along the pipe. The ratio of the density of the spheres to the fluid was varied between 1.04 and 0.96. The graphical results are (a) a ratio of mean sphere velocity to mean fluid velocity as a function of the density ratio and (b) longitudinal dispersion coefficient as a function of the density ratio. Theoretical results are also presented for the effect of both density ratio and sphere-to-pipe-diameter ratio upon the velocity ratio. No explanation is offered for the experimentally determined mean velocity of the spheres being greater than the fluid mean velocity (approximately 6% greater at a density ratio of 1.0).

M. R. Carstens, USA

4697. Clark, W. J., and Stephens, R. C., Flow measurement by square-edged orifice plates: pipe roughness effects, Instn. mech. Engr. Lond., Prepr., 12 pp.

Paper presents the results of experimental work carried out recently to determine the effects on the discharge coefficient of various degrees of pipe roughness adjacent to and at different distances from an orifice plate. Experiments were carried out for air flow in 12-, 6-, and 3-inch pipes and water flow in 3-inch pipes.

Downstream, severe incrustation has no significant effect. Upstream, the effects vary with degree of roughness, pipe diameter, m value, and Reynolds number. For an m value of 0.5 and severe conditions of roughness, the combined effects of roughness and pipe diminution produce disturbance factors of the order of 1.40, 1.17, and 1.08 respectively for 3-, 6-, and 12-inch pipes. A length of two diameters of rough pipe immediately upstream from an orifice plate gives an effect close to that which would be obtained for a very long rough pipe. It has been found possible to extrapolate the results to very large pipes.

One of the most important findings is that cleaning a rough upstream pipe adjacent to an orifice plate for a relatively short distance reduces errors which may be otherwise very considerable to within known small limits. A table detailing the extent of such cleaning for various pipe sizes, m values, and degrees of roughness is given.

It is recommended that, where reasonable accuracy is required in the flow measurement of dirty fluids, installations should be designed for easy periodic inspection and cleaning of the upstream pipe adjacent to the orifice plate. From authors' summary

4698. Allander, C., Measurement of rapidly varying liquid flow (in Swedish), *Tekn. Tidskr.* **88,** 19, 517–518, May 1958.

Brief description of a sensitive thermocouple probe arrangement suitable for measurement of small velocities.

N. H. Johannesen, England

4699. Accurate metering pump, *Chemical Product, United Kingdom* Nov. 1956, 458–459 (*E.T.D.*, 1957 p. 469–470).

Courtesy, European Technical Digests

4700. Ageikin, D. I., and Desova, A. A., An electromagnetic flowmeter (in Russian), *Automation and remote Control* **17,** 12, 1123–1127, 1957 [Translation of *Avtomatika i Telemekhanika* **17,** 12, 1123–1127, Dec. 1956. Copies obtainable from Consultants' Bureau, Inc., New York City.]

Paper describes the design of two circuit variants for electromagnetic flowmeters. Methods are examined for eliminating transformer emf, and a circuit is discussed for a secondary instrument of the compensation type which would eliminate the effect of fluctuations in line voltage. Experimental results are cited.

From authors' summary

4701. Doyle, J. P., Jr., Instrumentation and data handling methods for determining load distribution on wind-tunnel models by pressure distribution measurements, *AGARD Rep.* 114, 16 pp. + 13 figs., Apr./May 1957.

4702. Gelder, T. F., Droplet impingement and ingestion by supersonic nose inlet in subsonic tunnel conditions, *NACA TN* 4268, 28 pp. + 14 figs., May 1958.

The amount of water in cloud droplet form ingested by a full-scale supersonic nose inlet with conical center body was measured. Local and total water impingement rates on the cowl and center-body surfaces were also obtained. All measurements were made with a dye-tracer technique. Inlet angles of attack of 0° and 4.2°, droplet diameters from 11 to 20 microns, and ratios of inlet to free-stream velocity from 0.4 to 1.8 were studied. Measurements were confined to a free-stream Mach number of 0.237 and are extendable to other subsonic speeds by dimensionless impingement parameters. From author's summary

4703. Pasquarelli, C. G., Research on the velocity variations in an open-jet wind tunnel and attempts for their elimination (in Italian), *Ric. sci.* **27,** 10, 3001–3015, Oct. 1957.

The research was performed in a 400-mm ϕ wind tunnel of the Turin Polytechnical School, at a maximum velocity of 100 m/sec. By a hot-wire anemometer connected to an oscilloscope, well defined fundamental oscillations were detected, their frequency increasing by leaps and bounds with increasing velocity, and such that a whole number of half-wave lengths is contained in the length of the duct.

Attempts were made to attenuate the oscillations by aspirating the excess air flow at the divergent duct, just downstream of the open jet. A 7-hp centrifugal exhauster was utilized for that purpose, and various configurations of exhaust openings were tried between the bell-shaped collector and the diverger inlet. In all cases, although the power of the exhaust fan could not be considered small with respect to the maximum jet power (appr. 100hp), the result was completely unsatisfactory: only the air reflux at the outer rim of the bell could be eliminated, at least for velocities under 50 m/sec.

The author suggests finally a new possibility of solving the problem. From author's summary

4704. Murray, J. B., An experimental investigation of temperature and pressure recovery, running time and blockage characteristics of the UTIA 16 inch × 16 inch supersonic wind tunnel, *Univ. Toronto Inst. Aerophys. TN* 16, 12 pp. + 8 tables + 10 figs., Aug. 1957.

Tests have been conducted at a Mach number of 2.49 to investigate the effect of various cone model configurations on the pressure recovery in the sphere, running time and blockage area in the test section of the UTIA 16-inch by 16-inch supersonic blowdown wind tunnel. Further, the recovery temperature in the sphere was measured as a function of tunnel running time. No noticeable effect of cone angle or cone frontal area on pressure recovery or running time was detected. The cone angle was found to affect the cone frontal area at which blockage occurs. The recovery temperature in the sphere reaches equilibrium after about 15 seconds and is somewhat below the theoretical recovery temperature due to heat convection losses via the sphere walls to the surrounding atmosphere. From author's summary

4705. Bateman, T. E. B., and Lawrence, A. J., Experimental investigation of the pressure distribution at the centre-section of a sweptback wing at high subsonic speeds, *Aero. Res. Counc. Lond. curr. Pap.* 367, 13 pp. + 5 tables + 11 figs., 1957.

The uncertainty of the validity of theoretical estimates and the absence of experimental data for the pressure distribution at the center-section of a sweptback wing at high subsonic speeds led to the present tests. The measurements have been made on a 40° sweptback wing over the Mach number range 0.50 to 0.94, at zero incidence.

Given pressures are reached further aft at the center-section than on a section of the infinite sheared wing. In particular the supersonic region, when formed, occurs much further aft and the shock-wave moves quickly to a position close behind the trailing edge. The isobars lose their sweep in the neighborhood of the center-section and this reduces the critical Mach number from 0.38 for the sheared wing to 0.81 for the center-section. The maximum local Mach number at the center-section tends to a steady value of about 1.15 at high subsonic speeds.

Theoretical estimates of the pressure distributions on the sheared wing at zero incidence are shown to agree well with the measured values for speeds at which no shock-waves form, but estimates for the center-section agree well only at very low speeds.

At higher speeds (even at $M = 0.5$) the theory predicts too low a pressure over the forward half of the chord and too low a suction over the rear half, i.e., it underestimates the "center effect."
From authors' summary

4706. Wegener, P. P., and Mack, W. M., Condensation in supersonic and hypersonic wind tunnels, Advances in appl. Mech., **5,** (edited by Dryden, H. L., and von Karman, Th.), New York, Academic Press, 1958, pp. 307–459.

Excellent comprehensive survey of theoretical and experimental work on condensation, including both water condensation in supersonic tunnels and air condensation in hypersonic tunnels. Earlier work on condensation in steam nozzles is also discussed. Full account is given of equilibrium conditions, supersaturation, and effects of condensation nuclei. Effects of condensation on measurements in wind tunnels are discussed briefly. Useful list of 132 references is given. W. A. Mair, England

4707. Smelt, R., and Sivells, J. C., Design and operation of hypersonic wind tunnels, *AGARD Rep.* 135, 32 pp. + 1 table + 8 figs., July 1957.

Discusses problems of the operation of hypersonic wind tunnels, including air supply, diffuser efficiency, heater design and operation, nozzle design and calibration, and instrumentation. Real (imperfect) gas effects and the application of hypersonic wind-tunnel results to flight problems are also discussed. Some solutions are given, based on experience of the design and operation of the Gas Dynamics Facility at the Arnold Engineering Development Center. From authors' summary

4708. Seiff, A., The use of gun-launched models for experimental research at hypersonic speeds, *AGARD Rep.* 138, 10 pp. + 12 figs., July, 1957.

4709. Cox, R. N., and Winter, D. F. T., The light gas hypersonic gun tunnel at A. R. D. E. Fort Halstead, Kent, *AGARD Rep.* 139, 10 pp. + 14 figs., July 1957.

4710. Purser, P. E., and Bond, A. C., NACA hypersonic rocket and high-temperature jet facilities, *AGARD Rep.* 140, 7 pp. + 12 figs., July 1957.

4711. Ludwieg, H., Tube wind tunnel, a special type of blow-down tunnel, *AGARD Rep.* 143, 6 pp. + 6 figs., July 1957.

4712. Schultz, D. L., and Henshall, B. D., Hypersonic shock tube equipment at the National Physical Laboratory, U. K., *AGARD Rep.* 147, 9 pp. + 3 tables + 14 figs., July 1957.

4713. Knight, H. T., Piezoelectric detector for low-pressure shock waves, *Rev. sci. Instrum.* **29,** 2, 174–175 (Notes), Feb. 1958.

4714. Svenson, O., A contact extensometer for the recording of flight-load spectra, *AGARD Rep.* 121, 4 pp. + 7 figs., May 1957.

Thermodynamics

(See Revs. 4588, 4612, 4620, 4636, 4686, 4696, 4754, 4756, 4770, 4777)

Heat and Mass Transfer

(See also Revs. 4374, 4375, 4414, 4527, 4577, 4588, 4637, 4686, 4698, 4704, 4759, 4782, 4783, 4818)

4715. Grover, J. H., and Holter, W. H., Solution of the transient heat-conduction equation for an insulated, infinite metal slab, *Jet Propulsion* **27,** 12, 1249–1252, Dec. 1957.

Charts, of the well-known Gurney-Lurie type, are prepared for the heat-conduction equation when the radiation boundary condition is prescribed at one end of the slab, a condition $\partial T/\partial x = m\partial T/\partial t$ at the other end. G. Horvay, USA

4716. Przemieniecki, J. S., Electrical analogy for transient axisymmetrical heat flow, *J. aero. Sci.* **24,** 12, p. 922 (Readers' Forum), Dec. 1957.

4717. Bolte, W., Determination of the true qualities of a material from average values, especially when dealing with conductivity of heat (in German), *Brennstoff-Warme-Kraft* **9,** 8, 373–375, Aug. 1957.

4718. White, G. W. T., On the use of matrices for solving periodic heat flow problems, *Appl. sci. Res.* (*A*) **6,** 5/6, 433–444, 1957.

Author applies matrix formalism of four-terminal networks to express temperature and flux at cross section II in terms of conditions at cross section I. Various symmetry conditions are investigated. G. Horvay, USA

4719. Andriankin, E. I., and Ryzhov, O. S., Propagation of a nearly spherical thermal wave (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **115,** 5, 882–885, 1957 (translated from Russian by M. D. Friedman, 67 Reservoir St., Needham Heights, Mass. A-134, 5 pp.)

The heat conduction equation in an infinite stationary medium, having a small prescribed variation of density and temperature-dependent conductivity, is solved for a point source. The solution consists of the well-known similar solution of a constant-density medium and a correction term of density variation which, after linearization, is resolved into harmonic components.
L. S. Dzung, Switzerland

4720. Fedosov, A. I., Influence of surface-active substances on the movement of drops in liquids (in Russian), *Zh. fiz. Khimii* **30,** 1, 223–227, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 450.

An investigation was carried out to define more precisely the theory, put forward by A. N. Frumkin and V. G. Levich [*Zh. fiz. Khimii,* **21,** p. 1183, 1947]. for the evaluation of the frictional action on the movement of a drop in a liquid under the influence of surface-active substances. This precision concerns the application of a more accurate expression for the consistency of the flow of substance on the drop, and, actually, the dependence of the flow of substance is considered from the polar angle. The problem is solved of the diffusion of the dissolved substance in the moving drop. The differential equation of convectional diffusion, by means of discarding small terms and going over to new variables, leads to the usual equation of heat conductivity when the corresponding boundary conditions are operating. The solution of this equation, of quadratic form, gives the distribution of the concentration of the dissolved substance on the surface of the drop. An approximate formula is deduced for the concentration. As a consequence of the obtained dependence, a formula is derived for the calculation of the speed of motion of the drop, taking into account the frictional action of its movement by the surface active substance. An analysis is evolved of this formula and a comparison made with the analogous formula obtained by Frumkin and Levich. Yu. F. Dityakin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4721. Brevoort, M. J., and Arabian, Barbara D., Summary of experimental heat-transfer measurements in turbulent flow for a Mach number range from 0.87 to 5.05, *NACA TN* 4248, 8 pp. + 1 table + 15 figs., May 1958.

An axially symmetric annular nozzle was used to obtain essentially flat-plate data on turbulent heat-transfer coefficients

and temperature-recovery factors. The test results of this paper are for Mach numbers 0.87, 1.62, 2.06, 3.03, 3.90, and 5.05 and for a Reynolds number range of 1×10^6 to 9.5×10^6. These results are presented in the form of Stanton number and recovery factor as a function of Reynolds number. The Stanton number shows a systematic variation with Mach number. The recovery factor appears to be independent of the Mach number in the range of these tests. Both Stanton number and recovery factor show a decrease with an increase in Reynolds number.

From authors' summary

4722. Spalding, D. B., Heat transfer from surfaces of non-uniform temperature, *J. Fluid Mech.* **4,** 1, 22–31, May 1958.

An improvement is presented of Lighthill's method of calculating steady heat transfer from a surface of arbitrary temperature distribution to a laminar stream of arbitrary velocity distribution. It will be remembered that Lighthill's method, which allows the ratio between thermal and momentum boundary-layer thickness to vary, considers the case where the thermal boundary layer is much thinner than the momentum boundary layer, and, therefore, lying within a region of linear velocity profile.

This paper describes a correction to Lighthill's method which accounts for the nonlinearity of the velocity profile within the thermal boundary layer. It is claimed that this error in Lighthill's method is reduced to a maximum of 2.5% even for cases of a thick thermal boundary layer. In addition, an attempt is made to show that the Tribus-Klein correction to Lighthill's method may have adverse effects. The improvement may be summarized as consisting of (a) a better allowance for velocity profile nonlinearity; (b) the use of an enthalpy thickness for calculating the heat transfer over a finite surface area; and (c) a quadrature procedure for integrating the continuation equation for the boundary-layer thickness.

R. J. Mindak, USA

4723. Morgan, G. W., Pipkin, A. C., and Warner, W. H., On heat transfer in laminar boundary-layer flows of liquids having a very small Prandtl number, *J. aero. Sci.* **25,** 3, 173–180, Mar. 1958.

Authors present method of solving energy equation for laminar forced convection problems based on observation that, for very small Prandtl number, the viscous boundary layer is much narrower than the thermal boundary layer, so that velocity distribution is essentially potential over most of the thermal layer. General formulas so obtained are applied to give specific solutions for flow over wedges. Results for a flat plate are evaluated numerically and are compared with existing answers, thus yielding an indication of range of validity for authors' solution.

G. Power, England

4724. Gold, R. R., A note on the expressions for the local heat-transfer coefficient, *J. aero. Sci.* **25,** 3, 208–209 (Readers' Forum), Mar. 1958.

By consideration of available analytical results on local heat transfer from a two-dimensional steady laminar boundary layer in flow of air over a flat plate, it is demonstrated that the heat-transfer coefficient for a temperature range from 100° to 2000°R is practically independent of temperature. A simple empirical relation which describes the heat-transfer coefficient with good accuracy is presented. A similar relation is developed which describes the heat-transfer coefficient in a turbulent boundary layer. This equation contains the reference temperature as developed by Eckert. These simple relations should be useful for engineering calculations on heat transfer from an air stream to a flat plate under the condition that nowhere in the boundary layer is a temperature of 2000°R exceeded.

E. R. G. Eckert, USA

4725. Illingworth, C. R., The effects of a sound wave on the compressible boundary layer on a flat plate, *J. Fluid Mech.* **3,** 6, 471–493, Feb. 1958.

Formulas are obtained for the skin friction and the heat transfer for very high and very low frequencies of the sound wave. Different methods of simplifying the boundary-layer equations in unsteady compressible flow are briefly compared.

From author's summary by D. ter Haar, England

4726. Smith, A. G., and Spalding, D. B., Heat transfer in a laminar boundary layer with constant fluid properties and constant wall temperature, *J. roy. aero. Soc.* **62,** 565, 60–64 (Tech. Notes), Jan. 1958.

Approximate procedures are generally used to calculate heat transfer in a laminar boundary layer around objects of arbitrary shape because an exact solution of the velocity and temperature boundary layers is very tedious. The present paper simplifies a procedure previously presented by E. Eckert in which the problem is reduced to the solution of a first-order ordinary differential equation. The simplification is based on the fact that for wedge-type flow the connection of a parameter appearing in the differential equation and of the boundary-layer thickness parameter can be well approximated by a linear expression. This permits a solution of the differential equation by a simple quadrature. A calculated example shows good agreement with calculations by Eckert and Schuh.

E. R. G. Eckert, USA

4727. Kogan, M. G., Nonstationary thermal conductivity in laminar bodies (in Russian), *Soviet Phys. (JTP)* **2,** 3, 467–475, Jan. 1958. [Trans. from *Zh. Tekh. Fiz. Akad. Nauk SSSR* **27,** 3, 522–531, Mar. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Author considers nonstationary thermal conductivity in nonhomogeneous laminar bodies (one-dimensional, axially symmetric and centrally symmetric problems), due to the action of sources located within the layers and on surfaces of separation, including heat exchange with the surrounding medium (boundary conditions of the first, second, and third kind). Various heating conditions are investigated, namely transient, regulated, and stable (stationary and quasistationary) conditions. Examples of determinations of temperature distributions are given for sources of constant and periodically varying intensity (thermal waves).

From author's summary by H. D. Block, USA

4728. Sparrow, E. M., Hallman, T. M., and Siegel, R., Turbulent heat transfer in the thermal entrance region of a pipe with uniform heat flux, *Appl. Sci. Res. (A)* **7,** 1, 37–52, 1958.

Report derives local and fully developed Nusselt numbers for values: $0.7 \leqslant Pr$ = Prandtl number $\leqslant 100$, $5 \times 10^4 \leqslant Re$ = Reynolds number $\leqslant 5 \times 10^5$. Variation of l_e = thermal entrance length (heated length required to bring local Nusselt number within 5% of fully developed value) as function of Prandtl number and Reynolds number is studied.

Numerical solutions for fully developed flow and entrance flow are given. Comparison with other analytical investigations is given, as is comparison with experimental results for water and air. In general, agreement with experiment is fairly good. Analytical results also compare well with empirical correlation given by McAdams ["Heat transmission," 3rd ed., McGraw-Hill Book Co., Inc., New York, 1954]. Major result is marked decrease in entrance length as Prandtl number increases, and insensitivity of entrance length to Reynolds number. Thus, l_e at $Pr = 0.7$ is 12, 13, 14 for values of $Re = 5 \times 10^4$, 10^5, 5×10^5 respectively, and drops to $l_e = 4$ at $Pr = 10$, independently of Re.

Results complement those of Graetz [in Jakob, "Heat transfer," Vol. 1, John Wiley and Sons, New York, 1949] for laminar thermal entry region, and will be of interest in many fields, such as nuclear reactor design.

B. W. Augenstein, USA

4729. Longwell, P. A., Graphical solution of turbulent-flow diffusion equations, *AIChE J.* **3,** 3, 353–360, Sept. 1957.

Author extends the well-known graphical method of Schmidt, for the solution of the nonsteady heat-conduction equation, to the more general equation

$$\frac{\partial \phi}{\partial x} = f_1(y) \frac{\partial}{\partial y} f_2(y) \frac{\partial \phi}{dy}$$

by use of unequal y increments which accomplish a weighted average. The practical nature and precision (2-figure accuracy) of the method is shown by two examples, a laminar flow pipe heat transfer and a turbulent flow heat transfer. The former agrees well with the Graetz solution. Author fails to note that with very little additional work the graphical method can be further generalized to solve

$$\frac{\partial \phi}{\partial x} = f_1(y,\phi) \frac{\partial}{\partial y} f_2(y)\, g(\phi) \frac{\partial \phi}{\partial y}$$

and hence be suitable for cases in which the properties of the material are functions of the dependent variable.

H. W. Emmons, USA

4730. Lance, G. N., and DeLand, E. C., The steady, axially symmetric flow of a viscous fluid in a deep rotating cylinder heated from below, Univ. Calif. Publications in Engng. **5,** 6, 159–176 + 10 figs., 1957.

Paper presents an extension of the "dishpan" problem treated by Davies [*Phil. Trans. roy. Soc. Lond. (A)* **246,** June 1953; AMR **7** (1954), Rev. 1858] to cases where depth is comparable to radius and diameter. Axial symmetry and steady state are assumed, and perturbations from solid rotation are taken to be small. A linear problem is obtained in which the variables are separable. Solutions were determined by use of a differential analyzer and fluid motions are discussed.

S. Ostrach, USA

4731. St. Savulescu, Determination of boundary-layer characteristics by means of typical profiles of velocities and temperatures (in French), *Acad. Repub. Pop. Romane, Rev. Mĕcan. appl.* **2,** 2, 1957.

A new method for determining boundary-layer characteristics is described. Author considers that the new variable $\eta_\delta = \psi/\psi_\delta$, where $\psi = \int_0^y \rho u dy$ and $\psi_\delta = \int_0^\delta \rho u dy$, gives a turbulent character to the velocity profiles $u/u_e = u_a(\eta_\delta)$. Similar considerations are applied to the dimensionless temperature function $(E - E_w)/(E_e - E_w) = E_a(\eta_A)$, where $E = C_p T + u^2/2$.

By means of the typical velocity profiles $u_a = \eta_\delta^n$, $E_a \simeq \eta_A^{n_1}$ the friction and transfer coefficients and other boundary-layer characteristics may be readily obtained. Assumption is made that n and n_1 are constants having characteristic values both for laminar and turbulent regimes.

Staff, Revue de Mecanique Appliquee
Acad. Republ. Pop. Romane, Rumania

4732. Romanenko, S. V., Generalization of I. I. Novikov's paradox in the case of the flow of gas in conditions of convection heat exchange and friction (in Russian), *Izv. Kievsk. politekhn. in-ta* **18,** 326–332, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2018.

The fact is examined, as a paradox, that when there is adiabatic flow of gas along a cylindrical tube the alteration of the condition parameters is determinable in a well-defined manner (within the framework of an one-dimensional model) by assigning an initial and end value for the number M, and does not depend to any extent on the length of the conduit and the viscosity of the gas. This result is generalized for the case of a flow of gas along the tube at constant temperature in the presence of convection heat exchange between the gas and the walls of the tube. First of all, on the basis of the fundamental equation of the hydrodynamic theory of heat exchange, it is demonstrated that there exists a well-defined connection between the numbers M and $\sigma = T_0/T$ (where T_0 is the temperature of frictional action and T is the temperature of the wall). Then equations are deduced determining the relations between the end and the initial values of all the parameters of condition in functions from M_2/M_1 and σ_2/σ_1 (the index figures 1 and 2 indicate the initial and corresponding end values); that is, in the final calculation, from either the numbers M and σ, the equations only include the relations regarding heat capacity. In so doing the adiabatic flow is treated as a particular case. Further analysis shows that at the fixed initial conditions (the assigned values of M_1 and σ_1) the value of M_2 is determined by assigning the adduced length $\chi = \zeta x/2D$ (where x is the length of the tube, D its diameter, ζ the coefficient of resistance). In this way, the independence of the end condition from the parameters of the channel seems apparent. The investigation is based on the assumption of the independence of ζ from M up to $M = 1$.

A. A. Gukhman
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4733. Kudryashev, L. I., Generalization of the hydrodynamic theory of heat exchange to cover the case of the flow around bodies of arbitrary form (in Russian), *Trudi Ku'bysbevsk. aviats. in-ta* no. 2, 16–25, 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2001.

From the enquiry into the heat content of a flow of liquid between two sections, one in front of, the other a long way behind, the contour around which the flow is taking place, the following relation is deduced

$$N = \frac{C}{2} \frac{F_1}{F_0} Pk,$$

where N is the Nusselt number, P is the Pekle number, C is the general coefficient of resistance of the body, which comprises in itself not only the resistance to friction but also the resistance of the shape, F_0 is the general surface of the body being flown around, F_1 is the plane of the central section, k is the relation of the degree of loss of heat content in the thermal path to the depth of loss of impulse in the hydrodynamic track. This relation generalizes the known formula for the theory of hydrodynamic heat exchange to cover the case of the flow around a body of arbitrary shape with break-away of currents. It was shown that k maintains its value along the whole path far away from the body around which the flow is taking place.

L. N. Gutman
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4734. Grosh, R. J., and Cess, R. D., Heat transfer to fluids with low Prandtl numbers for flow across plates and cylinders of various cross section, *ASME Trans.* **80,** 3, 667–676, Apr. 1958.

Paper treats local and over-all heat-transfer coefficients analytically for one- and two-dimensional flow of a fluid with low Prandtl number (such as liquid metal) across a flat plate and cylinders of various cross section. Analytical work is based upon assumptions of constant thermal properties of fluid over temperature range of interest, velocity and temperature fields are steady and two-dimensional, eddy transport of heat is small in comparison to molecular conduction, fluid has low Prandtl number such that inviscid flow may be assumed without large error, and flow is incompressible and irrotational. Solutions for local and over-all heat-transfer coefficients are presented for case of flat plate having a constant surface temperature excess, and for case of

flat plate having constant surface heat flux. Solutions are presented for case where surface temperature for one side is representable by simple power series (distance coordinate independent variable).

For circular cylinders, solutions are presented for case of constant surface temperature excess and case of constant heat flux. Solutions are offered for cases where temperature excess on cylinder surface may be represented by a cosinusoidal deviation from constancy, and for case where temperature distribution on cylinder surface is representable by simple power series with (1-cos β) as independent variable, β being angular coordinate of position measured from stagnation point. Solution can be extended for cylinders of arbitrary cross section if stream and potential functions are known and incorporated into the solution. A comparison of inviscid theory and Pohlhausen's solution for laminar flow across a constant temperature flat plate, and with Squire's solution for flow about a constant temperate circular cylinder, show a deviation of 7 to 12% and 5 to 10%, respectively, in the Prandtl number range of 0.005 to 0.025, associated with liquid metals. The effect of longitudinal conduction (in the direction of fluid flow) is considered and author concludes this conduction may be neglected when considering external one- or two-dimensional flow of liquid metal. He also states that inviscid theory would seem to apply for case of liquid metals flowing at moderate velocities (eddy conduction small), and that method applied to circular cylinders may be extended to other cylinders by properly incorporating stream and potential functions.

C. R. Mischke, USA

4735. Lance, G. N., The effect of a vertical lapse rate of temperature on the spiral flow of a fluid in a heated rotating cylinder, *J. Fluid Mech.* **3,** 5, 523–530, Feb. 1958.

Experiments have been performed with a viscous fluid contained in a rotating cylinder heated from below. Previous theoretical explanations of the flow patterns obtained in these experiments assumed that the convective terms in the heat-transfer equation were negligible. The present paper gives a treatment which includes one of these convective terms. The results confirm the physical reasoning that, when the lapse rate is positive, the stability is increased and that the motion is therefore decreased.

From author's summary by J. V. Becker, USA

4736. Hama, F. R., and Recesso, J. V., The axisymmetric free-convection temperature field along a vertical thin cylinder, Inst. Fluid Dynam. appl. Math., Univ. Maryland TN BN-116, 35 pp. + 17 figs., Jan. 1958.

One major purpose of this paper on axisymmetric, laminar free-convection temperature field along a long, thin vertical cylinder is to examine the influence of large transverse curvature on the development of boundary layer.

The theoretical analysis patterns closely after Glauert-Lighthill's treatment of Pohlhausen method in which judicious selection of the velocity profile was made. Similar procedure was followed by the authors in the selection of temperature profile required in the energy integral equation for the boundary layer. When the calculated result on Nusselt number, for Prandtl number of 0.72, was compared with the exact solution of Sparrow and Gregg which is valid only for the region near the leading nose of the cylinder, some discrepancy was noticed. A simple but more or less arbitrary correction was then introduced to bring closer the calculated result and that given by Sparrow-Gregg.

Experiments involve the measurement of mean temperature field at several sections from the lower end of a heated 1/4-in. brass tube, 10 ft long. Possible disturbance from room draft was eliminated by suspending the brass tube inside a 6-in. Lucite tubing. It was found that the temperature distribution near the brass tube was logarithmic and, hence, differed considerably from that in the neighborhood of a flat plate. However, if such distribution were plotted against a dimensionless y-coordinate normalized by the integrated heated-layer thickness, it was in fair agreement with the flat plate solution. No velocity measurements were made.

Local Nusselt numbers calculated from the corrected theoretical result are shown to be in good agreement with experimental data. The heat transfer coefficient is much higher than that for the corresponding two-dimensional case, due to the thinner axisymmetric boundary layer. For the same reason, the location at which laminar-turbulent transition takes place has been found to be delayed considerably when compared with that for the two-dimensional plate.

The rather good agreement between theory and experiment was construed by the authors as indirect verification of theories of laminar, axisymmetric boundary layer developed by Glauert, Lighthill and others reviewed in the paper. B. T. Chao, USA

4737. Kozlova, A. N., The detection of free heat convection of air within an inclined cylinder of circular cross section (in Russian), *Ucb. zap. Molotovsk. in-ta* **9,** 4, 71–75, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3194.

Some experimental data are given on the free, laminar convection of air in a cylinder, closed at the bottom, inclined at 45°. Heat was applied to the bottom of the cylinder.

G. A. Tirskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4738. Pavlov, D. F., Structure of laminar thermal convection in air (in Russian), *Trudi Sredneaz. un-ta* no. 65, 3–17, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2019.

Results are published of the experimental investigation into the internal structure of the process of free convection appearing above the delimited surfaces. Descriptions are given of the apparatus, measuring instruments, and ways of carrying out the observations. The results of the experiments allowed three zones to be separated out in the convection flow, distinguished from one another not only in form but also in character of the process. The nethermost zone is the zone of origin, representing in the physical sense a laminar boundary layer where the heat is transmitted by means of molecular heat conductivity. To determine the height of this zone the known formula for ascertaining the thickness of the boundary layer was used. The next part of the flow is the zone of development, occupying by height 2/3rds of the flow. The third part is the zone of damping. The author made the following deductions as the result of the observations: (1) There is a tightening up of the unwarmed air from the side, which indicates large influence on the formation of flows; (2) the existence of a thin layer at the surface of the delimited areas, where nuclei of warmed air make their appearance, analogous to the strata in natural conditions [A. A. Skvortsov, *Trudi in-ta energetiki, Akad. Nauk UzSSR* no. 1, 1947]; (3) the free convection above the delimited surfaces in laboratory conditions bears no similarity to the natural process. It is only possible to speak of their analogous nature. The analysis of the experimental data showed that (1) the film state of convection, the laminar form, and the form similar to the position of the free movement above the horizontal surfaces can be properly observed with values for Grashof's number of: less than 500, from 5×10^2 to 1×10^5, from 10^5 to 10^6; (2) the distribution of the mean temperature with height in the flow is sufficiently well described by the progressive relation of the form $\Delta t = C \Delta t_0 z^{-1}$. The indicator of the step in this relation does not coincide with the indicator of step (−1) which enters in the part of the flow where the convection process may be regarded as of the automodel type [A. N. Gutman, *Prikl. Mat. Mekh.* **13,** no. 4, 1949; Ya. B. Zel'dovich, *Zh. eksper. teor. Fiziki* **7,** no. 12, 1937]. V. K. Baev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4739. Eckert, E. R. G., Schneider, P. J., Hayday, A. A., and Larson, R. M., Mass-transfer cooling of a laminar boundary layer by injection of a light-weight foreign gas, *Jet Propulsion* **28,** 1, 34–39, Jan. 1958.

This means of protecting the surfaces of high-speed aircraft, missiles, and satellites exposed to aerodynamic heating is investigated analytically. The differential equations for a nonisothermal binary boundary layer with variable fluid properties and zero pressure gradient are reduced to a set of ordinary equations, transformed into a system of integral equations, and solved by successive approximations using a Univac Scientific Computer. Temperature, mass concentration, and velocity profiles are calculated for a hydrogen-air boundary layer for free-stream Mach numbers up to 12 and for several wall-to-free-stream temperature ratios including the adiabatic-wall case. Local skin-friction coefficient and local Nusselt number are presented as functions of surface mass concentration; recovery temperature is given as a function of wall injection parameter. Effects of high thermal capacity and low density of hydrogen relative to air are shown to dominate over effects of high thermal conductivity relative to air and to markedly decrease skin friction and heat transfer under conditions of hypersonic flow. E. L. Knuth, USA

4740. Searle, R., and Gordon, K. F., Mass transfer between two liquids with chemical reaction, *AICE J.* **3,** 4, 490–496, Dec. 1957.

The ratio of the mass transfer coefficient between two liquid phases with chemical reaction k to one without chemical reaction k' is derived from the well-known two-film theory and the penetration theory. The penetration theory is based on a model of unsteady diffusion into an eddy which is momentarily resting at the interface. Experiment with a system consisting of a layer of water containing sodium hydroxide beneath a layer of isobutanol containing acetic acid is compared with the theories. Theoretical values of $(k/k') - 1$ are about 100% high at 0.005N, correct at 0.1N, and about 60% low at 1N. These discrepancies seem to be a function of the concentration of the phase in which the reaction is occurring. I. Sawai, Japan

4741. Mattern, R. V., Bilous, O., and Piret, E. L., Continuous flow stirred tank reactors: Solid-liquid systems, *AIChE J.* **3,** 4, 497–505, Dec. 1957.

The analytical treatment of the characteristics of solid particles, i.e. size, surface area, activity of catalyst or saturation of adsorbents, changing in the reactor is given from a simple consideration. The theory is extended to the cases of the open solid-flow system, of the choked solid-flow system where the particles are prevented from leaving the reactor, and of the enclosed solid-flow system where the solid is placed initially in the reactor. The theories are confirmed by the experiments on the mixing of sand-water system and on the dissolution of sodium chloride into concentrated brine. Undoubtedly, in these heterogeneous systems, performance is closely related to the operating condition and reactor design, but good agreement between theory and experiment was obtained. I. Sawai, Japan

4742. Galloway, L. R., Komarnicky, W., and Epstein, N., Effect of packing configuration on mass and heat transfer in beds of stacked spheres, *Canad. J. chem. Engng.* **35,** 4, 139–150, Dec. 1957.

Experimental measurements are reported on the simultaneous rates of mass and heat transfer for the surface evaporation of water into air from two orthorhombic, a rhombohedral, and two simple cubic assemblages of uniform celite spheres, in the particle Reynolds number range 300–1200. The measurements were confined to the predetermined constant-rate drying period of the spheres.

No appreciable differences in mass or heat-transfer factors were found for the various assemblages, except for the cubics, which exhibited slightly lower transfer factors than the other assemblages at the higher Reynolds numbers. The negative slope of the log j versus log Re curves was designated the "index of turbulence inhibition." This index was correlated with the projected fractional free area of the packings, as well as with the wall effect.

Various methods proposed by investigators of randomly packed beds for modifying the mass-transfer factor and/or the Reynolds number failed to improve the over-all correlation of the results. The inapplicability of a simple analogy between momentum and mass transfer, as proposed by Ergun, is demonstrated.

Based on the model of McHenry and Wilhelm, the magnitude of the axial mixing factor required to correct for the use of logarithmic mean potentials is indicated.

From authors' summary

4743. Spalding, D. B., Transport processes between fluids and clouds of suspended particles: some exact solutions, *Proc. roy. Soc. Lond.* (*A*) **242,** 1231, 430–442, Nov. 1957.

Paper relates to processes such as the burning of pulverized solid fuel and of liquid fuel sprays, absorption of a gas component by a solvent spray, etc., and takes account of convection and turbulent mixing of the cloud. The Eulerian equation of conservation for the steady process is shown to be transformable into the Fourier equation for unsteady heat transfer in a flowing medium. Exact solutions are given for a one-dimensional system, an axially symmetrical system, and the steady-flow homogeneous reactor. Numerical methods are indicated for more complex systems, and the possibility of solution by means of an analogue is pointed out.

From the author's summary by A. H. Shapiro, USA

4744. Armand, A. A., An investigation of the mechanism of displacement of a two-phase mixture along a vertical tube (in Russian), Hydrodynamics and heat exchange in boiling, in high-pressure boilers; Moscow, Akad. Nauk SSSR, 1955, 21–34; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3264.

A description is given of an installation for testing air-water mixtures in a vertical pipe of a diameter of 26 mm, and of the experiments made with this equipment, in which the resistance forces and the mixture density were measured. A number of empirical relationships are given, obtained from evaluation of the experimental results. V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4745. Haydon, D. A., An investigation of droplet oscillation during mass transfer. I. The conditions necessary, and the source of the energy for the oscillations, *Proc. roy. Soc. Lond.* (*A*) **243,** 1235, 483–491, Feb. 1958.

4746. Davies, T. V., and Haydon, D. A., An investigation of droplet oscillation during mass transfer. II. A dynamical investigation of oscillating spherical droplets, *Proc. roy. Soc. Lond.* (*A*) **243,** 1235, 492–499, Feb. 1958.

4747. Kachurin, L. G., Solution of the problem of solidification of a sphere, taking into account the variation of the temperature at the temperature of crystallization front during the process of solidification (in Russian), *Soviet Phys.*(*JTP*) **2,** 3, 485–498, Jan. 1958. [Trans. from *Zh. tekh. Fiz., Akad. Nauk SSSR* **27,** 3, 543–547, Mar. 1957. Obtainable from American Inst. of Physics, Inc., New York, N. Y.]

Consider a liquid sphere at the freezing temperature T_0, on whose surface at $r = R$ there is imposed at time $t = 0$ a temperature $T_1 < T_0$. Then an inward freezing wave will be initiated, this reaches at time t' the radius r'. If we regard the temperature distribution between r' and R, in first approximation, as that of the steady state, then we know the temperature gradient at r', hence also the speed of freezing (from the familiar relation which equates

latent heat evolved with the heat conducted away); hence, by integration, we may determine also the time of complete freezing of the sphere. Conversely, if we *assume* a law for the speed of freezing, we may determine, from the same relations, the temperature at the freezing front (which is no longer T_s), and the corresponding freezing time. Ignoring the modification required in the boundary condition at r', due to the appearance of a conductive temperature gradient also on the inner side of r', author adopts a law of freezing dictated by physical considerations (no reference given), and determines the corresponding law of undercooling at the freezing front. G. Horvay, USA

4748. Forster, H. K., Diffusion in a moving medium with time-dependent boundaries, *AIChE J.* **3,** 4, 535–538, Dec. 1957.

Author treats the convective heat-conduction equation as a succession of the ordinary equation for stationary media, with systematically recalculated boundary conditions. (The boundary motion is a *prescribed* function of time.) He then considers heat transfer to a growing spherical vapor bubble inside of a liquid, and compares his results with earlier results of Plesset and Zwick. G. Horvay, USA

4749. Schotte, W., Heat transfer to a gas-phase chemical reaction, *Indust. Engng. Chem.* **50,** 4, 683–690, Apr. 1958.

4750. Jakob, F., Method for standardizing heat exchangers, *Kaltetechnick* no. 3, 64–67, 1957 (*E.T.D.*, 1957, p. 839–840).

Description of a calculation method enabling all thermal flow characteristics of a countercurrent heat exchanger to be expressed by a single curve. It is used as a basis for standardization, 80 models being sufficient to meet all practical requirements.

Courtesy European Technical Digests

4751. Masubuchi, M., Control of multi-pass heat exchangers. Part I, Dynamic characteristics of two-pass heat exchangers (in Japanese), *Trans. Jap. Soc. mech. Engrs.* **24,** 139, 209–213, Mar. 1958.

Author analyzed 1,2,3,4—, $2n - 1$, $2n$ pass heat exchangers exactly. This paper contains the dynamical analysis of two-pass heat exchangers. The heat exchangers of this type contain both parallel and counterflow heat-exchange sections. Author obtained fundamental heat-exchange equations; system parameters are combined and arranged in dimensionless form, and, for the typical combinations of these system parameters, the transfer functions are obtained.

Author found third-order characteristic equations governing the heat-exchange processes. The equations have coefficients of complex number. He solves them graphically and numerically.

An example of frequency response is given and compared with simple parallel and counterflow heat exchanger in equal flow conditions.

These dynamic characteristics show that heat exchangers of this type may be conditionally stable.

From author's summary

4752. Gunthner, O., Cross-ribbed steel tubes as heat exchangers (in German), *Technik Forsch.* no. 92, p. 269, June 20, 1956 (*E.T.D.*, 1957, p. 122).

In order to obtain the best possible exchange of heat, steel tubes serving as heat exchangers are equipped with ribs, sheet metal helices, etc., to enlarge their effective surface. The "Cross-rib Steel Tube" is a particularly effective example.

The rib consists of four equal sections with narrow diagonal spaces between them, this separation being necessitated by the manufacturing process. The sections are welded on to the tube by a newly developed automatic, resistance welding machine. The spacing of the ribs can be as desired. The two opposite sections are welded to the tube at the same time, which makes for economy.

Tensile and other tests have revealed very high mechanical properties. The efficiency of the tubes as heat exchangers is illustrated by a diagram.

Courtesy European Technical Digests

4753. Lowenthal, G. C., A simple calibration technique for improving the accuracy of a Smith resistance thermometry bridge, *Brit. J. appl. Phys.* **8,** 2, 449–452, Nov. 1957.

The Smith resistance thermometry bridge used at Defence Standards Laboratories is subject to irregular drifts which cause errors exceeding ± 0.002 C between 0 and 100 C and ± 0.01 C at 630 C. These errors cannot be dealt with successfully by potentiometric calibrations. An analysis shows, however, that, provided certain conditions are satisfied, an external decade of stable 10Ω resistors can be used to reduce the errors to ± 0.0005 and ± 0.001C, respectively, since the calibration is sufficiently simple and quick to be repeated as often as required.

From author's summary

4754. Foure, C., Water-cooled thermocouple probe for high temperature gas: the whole of the probe, including the hot junction, is water-cooled (in French), *Rech. aéro.* p. 26, Mar./Apr. 1956 (*E.T.D.*, 1957, p. 388).

Courtesy European Technical Digests

4755. Trombe, R., and Foex, M., High temperature treatment in solar furnaces; a step toward an industrial application of solar energy (in French), *Metaux Corrosion Industries*, no. 367, 126–138, Mar. 1956 (*E.T.D.*, 1957, p. 38).

Courtesy European Technical Digests

Combustion

(See also Revs. 4498, 4601, 4743)

Book—4756. Gurvich, A. M., and Shaulov, Yu. Kh., Thermodynamic measurements by the method of explosion, and calculations of combustion processes (in Russian), Moscow, Izd-vo MGU, 1955, 165 pp. + illus. 6r. 40k; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 219.

Book describes methods of determining thermodynamic values by means of explosions in closed vessels and the measurement of the maximum explosion pressure, and also methods of calculation of chemical equilibrium, both for the combustion at constant volume and also at constant pressure. In chapter 1 the general principles for determining thermodynamic values by means of the explosion method are described. Chapter 2 describes the experimental setup for determining the maximum explosion pressure and also the principles on which the apparatus works and the construction of the various pressure indicators used in such investigations. In chapter 3 a picture is given of the physical reactions which take place in the bomb when the explosion takes place, and also an analysis is carried out of the basic assumptions on which further computations are made: the assumption that the combustion results in the establishment of chemical equilibrium in the mixture of products of combustion behind the reaction zone. Possible explanations are adduced for the divergence of the experimental values for the maximum explosion pressure from the calculated values based on the uncertainly determined thermodynamic constants. In addition, different sources of heat loss when the explosion takes place are examined, and their effect on measurement results.

In chapter 4 general views are expressed on the calculation of chemical equilibrium in a system of reactive ideal gases of constant volume and constant pressure. For the case of the reaction at constant volume an equation is recorded for the heat balance

both for the case when dissociation is not taken into account and also when dissociation is taken into account. Note is made of the fact that, when reaction at constant pressure takes place, combustion temperature is lower, while the calculation in this case is more complicated. In chapters 5 and 6 methods are detailed for calculation of combustion processes at constant volume and constant pressure. Equations are given for chemical equilibrium and physical equilibrium. Different schemes are put forward for evaluating solutions of such systems by the method of selection of one of the partial pressures. A method is indicated for calculating the maximum temperature of the explosion, and also of the maximum pressure, in the case of combustion at constant volume or of the maximum degree of expansion in the case of constant pressure. In chapter 7 an approximate method is described for the calculation of combustion at constant pressure, given in the works of Ya.B. Zel'dovich and A. I. Polyarnov "Calculations of heat processes at high temperature" [Bureau of new technics, **17,** 1957].

Chapter 8 consists of statements on the methods of solution of systems of equations for calculating combustion: on the method of selection of values of some unknowns, on the method of successive approximations, on the method of linking the systems of equations to the linear, if the approximate values of the unknown are available. The range of applicability of the different methods is scrutinized. In chapter 9 schemes are put forward of calculations used in determining, by means of the explosion method, the average thermal capacity and heat of dissociation, and also a method of introducing corrections in irregular distribution of temperature in the products of combustion. All the schemes of calculation have examples of numerically obtained solutions.

In the appendices to the book elementary information is given on statistical thermodynamics. Descriptions are given of statistical methods of calculating thermodynamic values, a method is put forward, and an example, of the calculation of entropy of the mixture of products of combustion and tables of some values, indispensible in thermodynamic calculations. V. V. Smirnov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4757. Larish, E., Burning in a chamber of variable cross section (in Russian), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 1, 1957.

Steady burning in a chamber of variable cross section with a central stabilizer is investigated. The corresponding integral equation is deduced and solved. Conditions are given for the chamber cross section ratio in order to obtain complete combustion at a given Mach number of the flow.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4758. Constantinescu, V. N., Combustion with low velocity in a moving homogeneous mixture (in Russian), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 2, 1957.

Author first discusses combustion in a moving incompressible mixture, both for channels with constant or variable cross section and for two-dimensional and axisymmetrical motions. Thus Tsien's treatment is extended to axisymmetrical motions and at the same time other combustion cases are considered, e.g., combustions starting from the walls.

The same problems are also studied for compressible motions of burning mixtures. In such cases the critical Mach number at which combustion can no longer be completely effectuated is calculated.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4759. Kumagai, S., and Isoda, H., Experimental study on evaporation and combustion of fuel droplets (in Japanese), *Science of Machine, Tokyo (Kikai No Kenkyu)* **4,** 6, 337–342, 1952.

This is part of an extended research aimed at explaining the phenomena of spray combustion. The spray is considered as being midway between a single drop and a diffusion flame, the intermediate stages being two drops, five and nine drops, course spray, fine spray, gas flame burning in air. It is felt that by solving the problems of the combustion of a single drop, and of the diffusion flame, the combustion phenomena of a spray will be better understood. On a film of a rotating drum the flame of a fuel droplet, suspended at the end of a silica filament of 0.1-mm diam, is photographed, along with a time mark. The life of the burning droplet is found to be directly proportional to the square of the initial diameter; the proportionality factor, termed "specific burning time", depends on the fuel used. Combustibility is determined by the physical properties such as boiling point, latent heat, specific heat, etc., while ignitibility is influenced also by the chemical activity. Evaporation rate is determined by heat-transfer processes, and it is directly proportional to the temperature difference between the drop and the surrounding gas. Four basic equations are given for the law of combustion and evaporation. The filament material has also some influence; in particular, platinum promoted the burning rate, suggesting a catalytic effect.

K. J. DeJuhasz, Germany

4760. Kumagai, S. and Kimura, I., Combustion of fuel droplets (in Japanese), *Science of Machine, Tokyo (Kikai No Kenkyu)* **3,** 8, 431–434, 1951.

Fuel droplet suspended in air at end of a thin silica filament was ignited and the diminishing diameter of the droplet, and the changing flame front, photographed by spark illumination by schlieren technique. The height of the flame above the center of the drop decreased in proportion to the diminishing diameter of the droplet; the height of the flame below the center of the droplet, and also the width of the flame on the horizontal section through the center of the droplet remained constant. Three fuels—cetane, *n*-heptane, and ethyl alcohol—were used. The features of the upper and lower regions of the flame are explained by considering them as a combination of source of fuel vapor with uniform air flow, and a cylindrical diffusion flame, respectively.

K. J. DeJuhasz, Germany

4761. Parker, W. G., A review of some unusual stationary flame reactions, *Combustion and Flame* **2,** 1, 69–82, Mar. 1958.

Because of their wide application, air flames have dominated combustion research hitherto. This brief review indicates that self-propagating flames are not confined to oxidation reactions by oxygen or even to oxidation reactions in the broadest sense.

From author's summary

4762. Rozlovskii, A. I., The kinetics of the reaction of some inflammable gas mixtures in the combustion and precombustion area and the structure of the interior part of the flame (in Russian), Avtoref. diss. dokt. Khim. n., N.-i, fix.-Khim. inpt, Moscow, 1956; *Ref. Zh. Mekh.* 1956, Rev. 5799.

4763. Peshkin, M. A., On the variation in intensity of change of burning time in the cylinder of an engine with benzine and benzole mixtures, *Soviet Phys. (JTP)* **2,** 5, 969–970, Feb. 1958. [Trans. of *Zh. tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 1064–1065, May. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

4764. Putnam, A. A., On the rational choice of flame-holder shape, *Jet Propulsion* **28,** 1, p. 60, Jan. 1958.

4765. Gluckstein, M. E., Note on 'Study of premixed flames using radioactive tracers', *Jet Propulsion* **27,** 10, 1102–1103, Oct. 1957.

4766. Neimark, Yu. I., and Aronovich, G. V., Conditions governing the self-excitation of the "singing" flame (in Russian), *Zh. eksp. teor. Fiz.* **28,** 5, 567–568, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 203.

The theoretical conditions were investigated of the appearance of self-oscillation in the so-called singing flame. The phenomenon of the singing flame consists of sounds emitted from a tube in which a gas burner has been placed; at the same time, not only was the oscillation of the column of gas enclosed in the tube observed but also the flame of the burner. On the basis of Rele's hypothesis ["Theory of sound," T.P. GTTI, 1944], the mechanism of the oscillation in the singing flame is qualitatively explained, and three idealized models of the phenomenon are examined, convection being disregarded. V. E. Doroshenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4767. Rasbash, D. J., and Rogowski, Z. W., Extinction of fires in liquids by cooling with water sprays, *Combustion and Flame* **1,** 4, 453–466, Dec. 1957.

4768. Shal'man, Yu. I., Investigation of the flame speed in an engine with spark ignition (in Russian), Avtoref diss. tekhn. n., In-t im P. I. Baranov N-va aviats prom-sti SSSR, Moscow, 1956; *Ref. Zh. Mekh.* 1956, Rev. 5798.

Acoustics

(See also Revs. 4579, 4694, 4725)

4769. Shumway, G., Sound velocity vs. temperature in water-saturated sediments, *Geophys.* **23,** 3, 494–505, July 1958.

Sound velocity versus temperature was measured in a continental shelf silt, a calcareous ooze, a deep-sea red clay, a continental slope clay, and a quartz sand, using a resonant-chamber technique. The temperature effect on these water-saturated sediments was approximately the same as the water alone; this similarity to water behavior would be expected inasmuch as the compressibility of a water-sediment mixture is dominantly due to the relatively large water compressibility. From author's summary

4770. Fisher, I. Z., The molecular theory of sound velocity in liquids, *Soviet Phys.(Acoustics)* **3,** 2, 223–224, Feb. 1958. [Trans. of *Akust. Zh., Akad. Nauk SSSR* **3,** 2, 206–207, Apr.-June 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

An idealized model of a one-dimensional monatomic liquid is assumed. An expression for the sound velocity for an arbitrary interatomic force potential is given, based upon classical statistical thermodynamics. Simplified expressions at limiting high and low temperatures are obtained. No immediate engineering applications are apparent. F. G. Blake, Jr., USA

4771. Van Der Veen, B., On the angle between wave front and displacement of plane acoustic waves in quartz, *Philips Res. Rep.* **12,** 4, 273–280, Aug. 1957.

The Green and Christoffel theory of propagation of plane acoustic waves in anisotropic media is used to show analytically that X-cut bars of quartz of any desired orientation with respect to the crystallographic axes can be produced with substantially zero coupling between the wanted longitudinal waves and the unwanted transverse waves in the bar by making the bar nonrectangular in shape. A curve is given relating the bar orientation in the crystal to its required degree of skewness.

W. W. Soroka, USA

4772. Kanevskii, I. N., and Rozenberg, L. D., Computation of the acoustic field in the focal region of a cylindrical focusing system (in Russian), *Soviet Phys.(Acoustics)* **3,** 1, 46–64, Dec. 1957. [Trans. from *Akust. Zh., Akad. Nauk SSSR* **3,** 1, Jan.-Mar. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Paper extends mathematical analysis of latter author on the acoustic field due to a cylindrical convergent wave front. Basic assumption is that wave length $\ll$ focal length. Expressions are derived for the modulus of the potential in the neighborhood of the focus and in the far field for cylindrical fronts of small, semicircular or arbitrary arc and infinite or finite length. These expressions are inapplicable in certain small regions close to the focus but a very large part of the field is calculable. Computations show that the results for infinite and finite fronts differ by at most 15–20%. M. J. P. Musgrave, England

4773. Isakovich, M. A., Scattering of acoustic waves at small inhomogeneities in a wave duct (in Russian), *Soviet Phys.(Acoustics)* **3,** 1, 35–45, Dec. 1957. [Trans. from *Akust. Zh., Akad. Nauk SSSR* **3,** 1, 37–45, Jan.-Mar. 1957. Copies obtainable from American Institute of Physics, Inc., New York, N. Y.]

Soviet acousticians have paid considerable attention to sound propagation in inhomogeneous media, particularly in media displaying a laminar structure and constant gradients. In the paper here reviewed, a perturbation method is used to study sound scattering by small inhomogeneities in a fluid bounded by two parallel planes. The first case analyzed is for a fluid displaying small local variations in sound velocity and bounded by two rigid planes. The second case, which has obvious practical application in the field of underwater acoustics, deals with a homogeneous liquid bounded by a rigid plane and a pressure-release surface displaying irregularities small in terms of wave lengths. The surface roughness is expressed in terms of a statistical distribution function, which is definite progress over the combination of sine waves by which the liquid surface is customarily described.

M. C. Junger, USA

4774. Glotov, V. P., The theory of the relaxational absorption and dispersion of sound in strong electrolytes which are not fully dissociated, *Soviet Phys. (Acoustics)* **3,** 3, 236–245, Feb. 1958. [Trans. of *Akust. Zh., Akad. Nauk SSSR* **3,** 3, 220–229, July-Sept. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Relazation theory is used to compute the anomalously large absorption (and dispersion) of sound which is observed in aqueous solutions of certain salts in the frequency range below 10^8 cps. The mechanism involved in the relaxation of electrolyte dissociation is examined by utilizing the thermodynamic potential of the actual solution in the computation. The derived formulas are used to make a numerical evaluation of the coefficient of sound absorption, the sound dispersion, and the relaxation time for an aqueous solution of $MgSO_4$. From author's summary

4775. Baranova, V. N., and Velizhnina, K. A., Acoustic parameters of certain sound-absorbent materials, *Soviet Phys.(Acoustics)* **3,** 2, 107–111, Feb. 1958. [Trans. of *Akust. Zh. Akad. Nauk SSSR* **3,** 2, 99–103, Apr.-June 1957. Copies obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Measurements are performed on the acoustic parameters of Soviet sound-absorbent materials: cotton wadding, glass wool, bonded glass fiber, mipor. The data are presented in the form of tables.

From authors' summary

4776. North, W. J., Transonic drag of several jet-noise suppressors, *NACA TN* 4269, 9 pp. + 14 figs., Apr. 1958.

One-fifth scale suppressors were tested at Mach numbers from 0.65 to 1.10 over a range of nozzle pressure ratios. Total and component drag coefficients are presented for the various models. Drag increases due to the suppressors are presented in terms of net thrust. Propulsive-thrust losses were calculated, and the results were converted into aircraft payload penalty.

From author's summary

4777. McSkimin, H. J., Ultrasonic pulse technique for measuring acoustic losses and velocities of propagation in liquids as a function of temperature and hydrostatic pressure, *J. acoust. Soc. Amer.* **29,** 11, 1185–1192, Nov. 1957.

A description is given of a method for making velocity and attenuation measurements for liquids under hydrostatic pressure. The method is an ultrasonic pulse technique. A wave generated in a fused quartz rod is transmitted over a fixed path length to another fused silica rod terminated by a non-reflecting surface. By comparing in time and amplitude a wave reflected from the termination with wave reflected from the first solid liquid interface, one can determine accurately the velocity and attenuation occurring in the liquid under pressure and temperature changes.

Measurements were made for carbon tetrachloride and Dow-Corning silicone fluids. Both liquids indicated a velocity increase of about 75% for pressures of 35,000 psi. The attenuation of carbon tetrachloride decreased with pressure while that for the silicone fluid first decreased and then increased. The decrease in carbon tetrachloride is ascribed to a volume viscosity effect while that for silicone was due to an increase in shear viscosity as a function of the pressure. The ultrasonic measurement of attenuation provides a very sensitive measure of the freezing pressure for a liquid. W. P. Mason, USA

4778. Arkhangel'skii, M., and Afanas'ev, V. Ia., Investigation of the photodiffusion method of visualizing ultrasonic fields *Soviet Phys.(Acoustics)* **3,** 3, 230–235, Feb. 1958. [Trans. of *Akust. Zh., Akad. Nauk SSSR* **3,** 3, 214–219, July-Sept. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Paper investigates the accelerating effect which ultrasonic waves impose upon the development process of the exposed photographic layer of ordinary photographic paper when the ultrasonic wave is normally incident. The paper determines the relative blackening as a function of the ultrasonic exposure time and the ultrasonic intensity.

Optimum conditions are specified for the visualization of the cross section of the ultrasonic beam and for the sensitivity of the method at a frequency of 2 megacycles. A convenient construction is described for the radiometer which is used to measure the intensity. From authors' summary

4779. Mikhailov, I. G., and Fedorova, N. M., The absorption of large amplitude ultrasonic waves in structured solutions, *Soviet Phys. (Acoustics)* **3,** 3, 256–259, Feb. 1958. [Trans. of *Akust. Zh., Akad. Nauk SSSR* **3,** 3, 239–242, July-Sept. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

The absorption of ultrasonic waves is investigated in solutions of polyisobutylene in benzene (MD 20,000, 98,000 and 180,000) and perbutane in toluene. The measurements were performed by the pulse method at a frequency of 5 megacycles. It was established that the structure of the solution is destroyed in polymer solutions, starting at a certain threshold intensity which is determined by the nature of the dissolved polymer and the solvent.

From authors' summary

4780. Merkulov, L. G., Design of ultrasonic concentrations, *Soviet Phys.(Acoustics)* **3,** 3, 246–255, Feb. 1958. [Trans. of *Akust. Zh., Akad. Nauk SSSR* **3,** 3, 239–242, July-Sept. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Author discusses an approximate theory and method of designing of ultrasonic concentrators which have shapes of conical, exponential, and catenoidal horns. The theory is based on considerations of longitudinal vibrations of rods with variable cross section. He has computed the resonant dimensions of the concentrators and the particle velocity gain coefficient. A catenoidal concentrator is shown to possess the greatest amplifying effect. However, for small ratios of the linear dimensions of the bases of the wide and narrow ends of the concentrator, all types of concentrators behave in a similar way. G. S. Verma, USA

Ballistics, Detonics (Explosions)

(See Rev. 4378)

Soil Mechanics, Seepage

(See also Revs. 4389, 4798, 4800)

4781. Ferrandon, J., The mechanics of permeable soils (in French), **Parts I, II, III** *Houille blanche* **9,** 4, 466–480, July-Aug. 1954; **10,** 1, 63–85, Feb. 1955; **10,** 2, 150–166, Mar.-Apr. 1955; **10,** 3, 408–410, July 1955.

The paper is a summary of a series of lectures delivered to engineering students at the Grenoble Polytechnic Institute during the 1953–1954 session. The object of the lectures was to examine those properties of permeable soils which are of special importance in practical problems.

The first part treats the laws of laminar flow, generalising Darcy's law for isotropic soils by introducing the permeability tensor. The second part deals with the limiting equilibrium of cohesive soils without internal friction, and of cohesionless soils. The analytical method of Cauchy is used and gives the failure lines as characteristic curves of a system of partial differential equations.

The third part considers the phenomena of propagation of discontinuities in a permeable soil taking into account the existence of both solid and liquid stages. Finally a note by M. F. Serre on the time element in the settlement of clay strata introduces the problem of foundation settlement in a very general manner.

From author's summary

4782. Shusherina, E. P., Instructional directives for investigating the subsidence of frozen soils when thawing (in Russian), Materialy po labor. issled. merzlykh gruntov. Sb. 2, Moscow, Izdvo *Akad. Nauk SSSR*, 1954, 138–150; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1026.

A description is given of the method for determining subsidence of frozen soils when thawing, using the apparatus of N. A. Tsytovich. Details are given of the appliances, the method of preparing samples, and the experimental procedure. The experimental data are recorded, and two ways for determining the coefficients of thawing and settlement are given. P. L. Ivanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4783. Ushkalov, V. P., Subsidence of building foundations on thawing frozen soils (in Russian), *Trudi n.-i. in-ta osnovanii i fundamentov* no. 26, 53–91, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1025.

Results are given of prolonged investigations under natural conditions on the subsidences of foundations and displacements above foundation level in buildings of office and residential character and in structures of a metallurgical works, erected on thawing frozen soil strata. From author's summary

4784. Sheikhet, M. N., Determination of loads of a friable soil on a hard, flexible pit-prop of round shape (in Russian), *Nauch. tr. po. vopr. gorn. dela. Mosk. gorn. in-ta* no. 13/14, 109–116, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1006.

It is assumed that in the concentric layer surrounding the timber a hydrostatic pressure is set up which reacts on the timber; the timber and the remaining part of the soil are considered to be hard. In solving the problem a whole series of unsubstantiated assumptions are made. As a result, a formula is obtained for determining the pressure on the pit-prop, in which there is a total of values with different magnitudes. A. M. Kochetkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4785. Krynkovskii, S. S., Strengthening ground support (prismatic foundations), *Trudi Mosk. energ. in-ta* no. 17, 54–84, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1014.

An account is given of the computation of massive prismatic foundations applicable in the design of supports for high-voltage transmission lines. The foundations are assumed to be absolutely hard. The ground is examined as an elastic plastic body, the relation between load and deformation following Prandtl's curve. The resistance of the ground is taken to be proportional to the displacement, while the coefficient of proportionality varies with the depth according to the linear principle. The computation is carried out by means of the boundary condition, which is determined by the loss of stability. Displacement of the foundation in the moment of loss of stability is taken to be a turn of the foundation round some point and a vertical subsidence (the horizontal displacement is not taken into account). Criteria are established for the applicability of the formulas for calculation; theoretical computations are compared with the experimental data. The study appears to be a further development of S. M. Kudrin's method ["Ustoichivost' opor. v. gruntakh," chap. 1. Gosenergoizdat, 1936].

P. I. Ivanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4786. Kononenko, P. S., An investigation into the filtration and stone pitching of the slopes of earth dams (in Russian), *Inform. byul. Dneprostroya* pp. 17–19, July 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8273.

It is demonstrated on a concrete example that the existing formulas for determining the weight or size of the stones of a pitched slope, as used for the protection of earth dams, give widely diverging results. Initial experiments are described, made in a launder of 35-m length, 3-m width, and 3-m depth, with wave heights up to 0.8 meter. This launder was found to be too short, and it was subsequently lengthened to 50 meters.

The results of these first experiments testify, in the opinion of the author, to the possibility of using a single-layer filter as a substream for a stone-pitching protection.

B. A. Pyshkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4787. Skempton, A. W., and Bjerrum, L., A contribution to the settlement analysis of foundations of clay, *Géotechnique, Lond.* **7,** 4, 168–178, Dec. 1957.

The settlement of a foundation on a saturated clay is composed chiefly of the "immediate" settlement due to deformations taking place at constant volume, and the "consolidation" settlement due to volume reduction consequent upon the dissipation of pore pressures. This latter component is therefore dependent on the pore pressures set up by the foundation load, and these pore pressures are themselves dependent on the type of clay. An approximate theory is described which takes account of the type of clay; and comparisons with observed settlements in a number of practical cases show the theory to be an improvement on existing methods of calculation. From authors' summary

Micromeritics

(See also Revs. 4332, 4743, 4745, 4746, 4781, 4799)

4788. Drozdov, V. F., An investigation of the working of cyclone separators for gas-cleaning in tractor gas plants (in Russian), Gasification and purification of gas in tractor power-gas plants, Moscow, Mashgiz, 1956, 49–63; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3270.

An experimental investigation of the influence of different parameters of a cyclone (centrifugal purifier) on its performance. It is found that, with increase of the velocity of the mixture entering the cyclone, from 9.5 m/sec to 20.4 m/sec., the degree of purification of the gas in the cyclone is increased from 85.5 to 93.5%, and the hydraulic resistance from 45 to 170 mm/water. The initial concentration of the dust within the limits of 1 to 5 g/m^3 does not influence the degree of purification, nor the hydraulic resistance of the cyclone. In cyclones with a fully-developed, cylindrical part, the height of the discharge pipe and the opening angle of the cone have practically no influence on the degree of purification and the hydraulic resistance of the cyclone. In conical cyclones with an abbreviated cylindrical part the degree of purification increases with decreasing opening angle of the cone, while the hydraulic resistance does not at the same time increase. With decreasing diameter of the cylindrical part and discharge pipe, both the degree of purification and the hydraulic resistance increase. The same takes place with reduction of the diameter of the cylindrical part of the cyclone.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4789. Orr, C., and Martin, R. A., Thermal precipitator for continuous aerosol sampling, *Rev. sci. Instrum.* **29,** 2, 129–130, Feb. 1958.

Thermal precipitation is attractive for airborne particle collection because of the high collection efficiencies which may be attained and the convenient examination of the deposit. Most thermal precipitators, however, have very low sampling capacities or flow rates. To take fullest advantage of the desirable features of thermal precipitation, a new precipitator was designed and constructed. It operated continuously, and deposited particles upon a moving tape or substrate. Complete collection of particles resolvable with electron microscope was attained in a 3-in. diameter precipitating zone at a flow rate of 1 l/min.

From authors' summary

4790. Werminghoff, E., Function and construction of modern automobile carburetors (in German), *Automobiltechn. Zeitschr.* **59,** 9–10, 11 pp. + 20 figs., Sept.-Oct. 1957.

Modern carburetors have to satisfy several, sometimes conflicting, requirements: good acceleration and hill-climbing ability at low fuel consumption; good starting in all weather conditions, good part-load and no-load operation; insensitivity to fuel characteristics; independence from position of the carburetor; freedom from freezing and vapor lock; reliability; simple and inexpensive construction; few types for large number of applications. To satisfy all these and other requirements necessitates complications in the design. A large number of German and other carburetors are illustrated and critically described, among them: Solex, S.U., Weber, Zenith, Carter, Holley, Stromberg, Solex-register, Solex- Horizontal-register, Ford-Doppelregister. (While this paper does not treat sprays and drops in particular, its inclusion is justified because of its up-to-date information on modern carburetors as fuel spray generating devices.) K. J. DeJuhasz, Germany

4791. Pilcher, M., and Thomas, R. E., Drop-size distribution of fuel sprays, Amer. Chem Soc., Advances in Chem. Series no. 20, 155–165, 5 figs., 77 ref., 1958.

Basic requirement for a systematic research on liquid fuel combustion is the accurate determination of drop-size distribution in the fuel spray.

Experimental methods for determining the drop-size distribution of fuel sprays are reviewed. The procedures described are of six general types: microscopic examination of drops collected on slides or in cells; freezing of drops in spray followed by sieving; direct photographic methods; optical methods based on the scattering or absorption of light; electronic and radioautographic techniques; and selective impaction. Advantages and disadvantages

of each method are pointed out and special attention is given to the importance of representative sampling of the spray. Mathematical expressions for basic drop-size distributions are included. Averages and moments of the length-, surface-, and volume-weighted forms of these distributions are summarized. Principal relations existing among the corresponding arithmetic, geometric, and harmonic means are tabulated. Formulas for (1) normal-size, (2) log-normal-size, (3) Rosin-Rammler, and (4) Nukiyama-Tanasawa distributions are given.

K. J. DeJuhasz, Germany

4792. Shevyakhova, I. P., and Smirnov, N. I., Movement of drops of variable mass in a liquid medium (in Russian), *Zh. priklad. Khim.* **29,** 2, 183–193, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 448.

The movement of drops is observed in systems with the capacity for reciprocal solution. It is shown that the characteristics of the drop-movement, dissolving in the surrounding liquid medium, differ from the calculated values for insoluble drops by up to 30 to 35%. From the analysis of the differential equations of the drop (or medium) and the kinetics of the solution of the drop in the medium or the medium in the drop, nondimensional criteria are established which should enter into criterial dependence. Speed measurements were made of the movement of drops of different substances in distilled water, aniline and isobutyl alcohol. On the basis of the experiments criterial equations were evolved, characterizing the movement of drops of variable mass in a medium for a turbulent and a transitional region.

Yu. F. Dityakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4793. O'Donnell, T., Edwards, D. H., Collis-George, N., and Youngs, E. G., The recording of pressure distributions in porous media during fluid flow experiments, *J. sci. Instrum.* **35,** 2, 63–64, Feb. 1958.

A null-point method is described of recording in a short time interval pressure distributions in a porous medium during fluid flow experiments. Small cells, buried at numerous points in the porous material, measure the pressure distribution which is recorded in a separate laboratory.

From authors' summary

4794. Loeffler, A. L., Jr., and Perlmutter, M., Turbulent flow through porous resistances slightly inclined to the flow direction, *NACA TN* 4221, 14 pp. + 12 fig., Feb. 1958.

Analytical and experimental studies were made of turbulent airflow through a porous resistance inclined at a small angle, $3\text{-}1/2^{\circ}$, to the flow direction. The analytical studies were made assuming incompressible uniform flow with an unknown parameter β, defined as the fraction of the original momentum transferred to the fluid remaining in the channel by the fluid entering the porous resistance. The results of these studies are summarized as follows: (1) It is possible, by shaping the wall of an inclined-flow apparatus where the angle between the incoming flow and porous wall is small, to obtain uniform flow out of the porous wall. (2) The theory developed in this report can be successfully employed to predict the approximate wall shape needed to give uniform flow out of the porous wall if the value of β is known. (3) Values of β of 0 and 0.2 were obtained experimentally for the perforated plate and plate-cloth resistances, respectively, for the range of conditions studied. (4) Uniform flow through the porous wall is attained at the expense of increased loss of total pressure.

From authors' summary by M. H. Bertram, USA

4795. Oroveanu, T., and Pascal, H., On the motion of a compressible mixture of liquid and gas through a porous medium (in French), *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2,** 1, 1957.

Authors discuss the problem of a mixture of liquid and gas (a nonhomogeneous fluid consisting of a liquid phase and of a gaseous one, the latter being partially dissolved into a liquid) flowing through a homogeneous and isotropic medium. A state equation of the mixture is established assuming the two phases to be compressible and the evolution polytropic. The equation thus found is then particularized for the case of isothermic evolution, which is close enough to reality. Further, the motion equation of the mixture is deduced, assuming Darcy's law as valid, and the case of steady flow is discussed.

Staff, Revue de Mécanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4796. Fil'chakov, P. F., Method of successive conforming reflections and its application to filtration problems. I (in Russian), *Ukr. matem. Zh.* **7,** 4, 453–470; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2100.

The first two paragraphs contain an account of earlier work done by the same author [*Dokladi Akad. Nauk SSSR* **101,** no. 1, 1955] (with corrections of the misprints made therein). In paragraph 3 a process, useful in practice, is given of a graphical interpretation, applicable in the theory of filtration, of the method "turning (around) channels." In paragraph 4 the method described is used in the calculation of a plane steady filtration (following d'Arcy's principle) on the bases: (1) of a plane dam apron with an absolutely impermeable channel; (2) of a plane dam apron with three absolutely impermeable channels; (3) of a rectangular dam apron with two absolutely impermeable channels and a front to the apron; (4) of a dam apron of a practical outline with an absolutely impermeable apron front and channel, on the assumption that the homogeneous permeable foundation has unbounded capacity. In the case of the dam apron with several channels, as is customary, it is assumed that each of the channels can be opened up independently from the other channels. In so doing, the horizontal parts of the dam apron between every two adjacent channels are divided into two parts, proportionally to the length of the channels, and each channel is "turned" together with the adjoining parts of the horizontal portions of the dam apron. As is known, the independent turning of channels is possible in practice when the distance between two neighboring channels is not less than the sum of the length of these channels. When examining a dam apron of a practical (type of) outline by other than the method of "turning channels," use is made of the adduction of a semi-infinite rectangular dam apron to a plane dam apron (with an infinite depth of foundation).

In paragraph 5, in a hundred numerical examples, a comparison is made of the results of calculations obtained by the graphical method demonstrated in the paper with the results of calculations by means of the precise theoretical solution in the case of filtration (infiltration) through the foundation of a plane dam apron with one or two absolutely impermeable channels and a plane apron front (when there is infinite depth of the foundation). The comparison cited testifies to the practical acceptability of the graphical method expounded in the work for the calculation of the filtration. In paragraph 6 (the last) some indications are given for the use of the described method in the case of a permeable foundation of limited capacity conditioned by the proviso that the capacity of the foundation is not less than double the length of the projection of the subterranean contour of the concrete dam.

S. N. Numerov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4797. Yushmanov, O. L., Sand traps in canals (in Russian), *Gidrotekhn. i melioratsiya* no. 1, 28–34, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 534.

A method is set forth for the removal of bottom and just above bottom deposits from irrigation canals with the minimum consumption of water.

Openings for the water are made immediately at the bottom on the convex bank of the canal, using pipes of rectangular section. These pipes have a height of not less than 1/4 of the depth, and number not less than 2-3. The discharge of water from the outlets is controlled by shields. According to author's experiments, in order to remove all deposits of sediment in the just above bottom layer a consumption of water amounting to 3 to 5% of the delivery capacity of the canal is sufficient. Approximate formulas are given to determine the indispensable angle of plane deflection in the flow.

A. S. Ofitserov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4798. Ivanov, N. F., Salekhov, G. S., and Svirskii, I. V., Determination of the optimum conditions of exploitation of petroleum wells in beds with elastic conditions (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR*, ser. *fiz.-matem. i tekhn. nauk* no. 5, 40-51, 1954; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6755.

It is shown that in seams having plastic conditions in the presence of a purely petroleum zone the greatest total yield can be obtained by reducing the pressure on the faces of the well to a critical value P_{cr} as quickly as the technical conditions permit.

In paragraph [1], authors give the solution of the problem for one well, the porosity of the bed being considered constant. On the basis of the formula relating the pressure at the face of the well to its weight output, it is shown that the solution of the problem is the output G_{cr} at which the pressure on the face is equal to P_{cr}.

In paragraph [2], authors examine the case when the porosity of the medium differs at different points of the seam and when a multiple-well system is operated.

The pressure function R is introduced, as well as the operation of the i^{th} well of the system with pressure R_i at the face with operation of the same well at a pressure $R_i^* < R_i$. Investigating the function $R_1 = R_i^* - R_i$, authors show that at the face and at all points of the bed $R_1 \leqslant 0$; i.e., in the second conditions of operation the yield of petroleum will be greater than in the first, otherwise the greatest yield will be when the pressures on the faces of the wells are maintained at a level equal to the critical.

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Meteorology, Oceanography

(See also Rev. 4714, 4730)

4799. Kozlov, A. L., and Minskii, E. M., Basic principles for the rational treatment of sites of gas sources (in Russian), Voprosy razrabotki i ekspluatatsii gozovykh mestorozhdenii, 1953 3-52; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2101.

The first part of the article gives the history of the development of methods of handling sources of gas formation, which the authors subdivide into three stages: unsystematic methods; empirical methods of treatment, characterized by the application of treatment to gas sources of the (to-day) out-moded principles used in developing sources of petroleum; and the third stage, characterized by the application of a complex system of planning, based on geological data, underground gas hydromechanics, the technology of gas production, and the economics of the gas industry. In the second part, examination is made of the fundamental nature of the working of gas sources. A definition is given for the concept "a system of treatment," and three periods in the exploitation of gas sources are described: The first period, when the delivery of gas in the gas conduits is carried out by means of the inate gas pressure; the second period, when, in order to drive the gas through the pipe conduits, a main compressor station is installed near the gas source; and the third period, when the pressure in the stratum is so reduced that it is more profitable to use the gas locally. By the expression "rational working system of treatment" is to be understood the extraction of the required quantity of gas while working the smallest number of bores. The third part of the article is devoted to the geological aspects of the structure of the sources of gas formation. An examination is made of the conditions of gas occlusion in the earth's core, pressure in the gas layer, and the features of gas-containing strata.

The fourth part is taken up by the hydrodynamic principles concerned in the working of gas sources. Together with methods of determination of the fall in pressure in the gas strata and the progressive movement of water, questions are discussed regarding the degree and character of the opening up of the stratum, the determination of loss pf pressure in the bore of the well, the volume of the working yield of the wells and the diameters of the draw-off pipes, the determination of the required number of wells. In the fifth part an investigation is made of the industrial testing of gas wells. The method proposed by E. M. Minskii for analyzing the results of gas well tests is described; this is based on a two-term formula for the flow of gas to the surface of the well and permits the determination of the coefficient of resistance to filtration and the quantity of free yield. A brief examination is made of existing methods for ascertaining the permeability of the stratum according to the well test data. In conclusion, a brief resumé is given of the basic principles governing the working of gas sources.

B. B. Lapuk

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—4800. Blizniak, E. V., Belikov, E. F., and Belyi, L. D., Water power investigations [Vodnochergeticheskie izyskaniia], Moscow, Gosenergoizdat., 1957, 320 pp. $1.75.

Contents of this textbook are cartography and topometry, hydrometry and meteorology, geomorphology and hydrogeology, soil investigations. The senior author, Prof. Blizniak, has been active in river investigations since 1912; his experience penetrates all chapters. Emphasis is on practical application; the book has value for students and engineers. Reviewer was pleased to find several figures from his textbook, 1939, with no reference, however.

S. Kolupaila, USA

4801. Felsenbaum, A. I., A theory of ocean currents (in Russian), *Trudi Gos. okeanograph. in-ta* no. 29, 85-91, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3082.

The purpose of the paper is to determine established currents, density distribution and level of the sea, as conditioned by wind conditions. 1. Case of a deep sea: The starting equations are two expressions of motion containing terms determined by the turbulent exchange in the horizontal and vertical directions, the Coriolis forces, and the pressure gradients; the hydrostatic equation, and the condition of continuity. All these equations are linear. The boundary conditions are the condition of equality of the components of the frictional force at the air-water interface, and the condition of adhesion of the liquid to the sea bottom. An equation is derived for the stream function in which the term governed by the variation in the Coriolis parameter and the latitude is eliminated. Then, assuming the stream function to be known, the density distribution is determined by means of the density model of V. B. Stockman. Finally, from the known density field, the physical sea level is determined by the hydrostatic equation.

To determine the velocities at different levels, author returns again to the equations of motion, but considers the density, and consequently the pressure, to be known. The speed of the current is resolved into two components: gradient and drift. The gradient component is assumed to be geostrophic, while the purely drift component is written in the form of an Ekman solution.

2. Case of a shallow sea. In this case, terms governed by the Coriolis force and horizontal mixing are omitted, while the slope

of the level is easily determined by the stream function. Author has recourse to a solution for variable sea depth and variable coefficient of vertical mixing. The method of solution is the same as that for a deep sea.

Author does not determine the stream function, but indicates that it can be found by numerical integration of the equation obtained.

A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4802. Brovikov, I. S., Swells in a shallow sea caused by wind (in Russian), *Trudi Okeanogr. in-ta* no. 26, 164-189, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 562.

A method is shown for the calculation of the factors in wind wave formation in shallow water. Author proceeds via the equation of energetical balance of waves.

It is assumed that the energy transferred by the wind consists of two parts: the energy derived from the irregular distribution of the normal pressure of the wind along the wave profile, and the energy created by the mean tangential pressure of the wind.

Formulas determining the indicated quantities through the wave elements are obtained on the basis of concepts put forward by Sverdrup and Munk. The energy lost by the waves during their spread in shallow water is shown as the sum of three items. The first determines the loss of energy caused by friction along the bottom during the unimpeded periodic movement of water on the bottom; the second when there is progressive movement of the wave genesis; the third, accepted as the cause of the main loss of energy, due to the partial disruption of the waves. The destruction of the waves can be explained by the change in form of the wave, resulting from the speed variations at different points of the wave profile. It is assumed that the mass of water, thrown from the crest of the waves when being disrupted, causes an inshore countercurrent. The constructed equation for the energy of wind waves in shallow water contains two unknown functions: the height of the waves and their length. Author obtains his second equation by introducing the hypothesis that the quantity of energy derived from the wind is proportional to the square of the wind velocity.

Two problems were investigated on the basis of the solution of the constructed formulas: the evolution of curves in shallow water of constant depth and the deformation of deep sea waves on their approach to the coast. Both problems were solved without taking into account the statistical characteristics of wind wave elements in shallow water. Tables were made to determine the dimensions of wind waves at different wind speeds for water basins with depths of 5, 10, 15 and 20 m. The application of the constructed equation to the problem of the deformation of waves near the shore made it possible to frame the following deductions: if the length of the waves is less than a certain critical length, then, on approach to the shore, the waves will increase both in length and in height. If, however, the length of the wind waves is greater than the said critical length, then the height and length of the waves will decrease progressively as the waves approach the shore.

Yu. M. Krylov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4803. Belova, M. N., The theory of pneumatic wave damping, (in Russian), *Gidrotekhn. str-vo.* no. 5, 46-48, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3081.

As pointed out by the author, the efficacy of a pneumatic wave breaker depends primarily on the rate of ascent of the air bubbles. Consequently, the construction of a systematic theory of pneumatic wave damping depends on study of the relationship between the rate of ascent of the bubbles and the characteristics of the wave breaker: diameter of the pipe opening, pressure gradient, etc. Paper reports the results of full-scale tests. Kinematographic records were used to determine the rate of ascent of the bubbles under different conditions. The results show that: (1) The presence of an excess pressure in the pipe has practically no influence on the combined velocity of ascent of the bubbles; (2) the orientation of the airholes influences the velocity only in the neighborhood of the holes, i.e. at a sufficient depth; (3) apparently the fundamental factor influencing the rate of ascent is the diameter of the hold.

N. I. Moiseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4804. Pervurina, T. P., Zhukova, K. B., and Lundberg, O. R., Harmonic analysis of diurnal (24-hr) investigation of tides (in Russian), *Trudi Gosokeanogr. in-ta* no. 30, 226-241, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 570.

Authors put forward a series of qualitative concepts, relating to means of arranging observations on in-flowing and out-flowing tides. In addition, in the study, an evaluation is made of the astronomical conditions at the time the observations were made; a harmonic analysis of the 12-hour and 24-hour tidal flow is made; and methods for selecting harmonic constants are given.

A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4805. Cook, J. C., The design of a crevasse detector for polar exploration, *J. Franklin Inst.* **264,** 5, 361-378, Nov. 1957.

4806. Murgatroyd, R. J., Winds and temperatures between 20 km and 100 km—a review, *Quart. J. roy. meteor. Soc.* **83,** 358, 417-458, Oct. 1957.

4807. Dunskii, V. F., Paths of hot jets in the layer of the atmosphere just above the ground, *Soviet Phys. (JTP)* **2,** 5, 962-968, Feb. 1958. [Trans. of *Zh. tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 1056-1063, May 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N. Y.]

Paper presents some experimental results of the paths of hot jets in the layer of the atmosphere just above the ground. In calm air or in very weak wind the hot jet rises from the ground appreciably. Decrease of the temperature and increase of wind speed reduce this rise of jet trajectory. These experimental results check very well with the formula for the trajectory of a hot jet under equilibrium conditions of the bottom layer of the air, which the author gave in a previous paper.

S. I. Pai, USA

4808. Tsuwa, H., and Tanaka, Y., On a jet stream air-micrometer, *Technol. Rep. Osaka Univ.* **7,** 231/256, 109-116, Mar. 1957.

4809. Matveev, L. T., Vertical currents in the atmosphere's boundary layer (in Russian), *Izv. Akad. Nauk SSSR, Ser. geofiz.* no. 5, 453-461, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2073.

A description is given of the calculations for the vertical movements in the friction layer of the atmosphere taking into account the thermal stability, the roughness, velocity of the flow and the latitude of the place. The vertical velocity is determined from the equation of continuity. The horizontal components of the velocity of movement in the boundary layer are found from the solution of the equations of movement, in which the inertia terms are discarded. Assuming that the alteration of the coefficient of turbulence k with the height z takes the form of $k = k_\infty(1 + \epsilon - e^{-mz})$, author obtains for the complex velocity a hypergeometrical equation and makes use of the already prepared solutions, evolved earlier by A. A. Dorodnitsyn [*Dokladi Akad. Nauk SSSR* **30,** no. 5, 1941] and M. E. Shvets [*Dokladi Akad. Nauk SSSR* **30,** no. 8, 1941].

The arbitrary constants are determined by the use of the law of the change of wind with height in the layer near the earth

$$c = \frac{\nu_*^2}{mk_\infty(1-\eta_0)} \ln \frac{\eta}{\eta_0}(\cos\alpha_0 + i\sin\alpha_0)$$

Here c is the complex velocity, $\nu_* = \sqrt{\tau_0/\rho_0}$ is the dynamic velocity of the flow, α_0 is the angle of deviation of the wind from the isobar near the earth, $\eta = (1+\epsilon)e^{mz} - 1$, $\eta_0 = \epsilon$. In the end, summing-up when evaluating the characteristics of turbulence exchange, m, k_∞, ν_* are determined through the geostrophic velocity, the roughness parameter, the geographical latitude of the locality, and the angle α_0. Having obtained expressions for the distribution of the wind velocity and of the turbulent tangential pressure with height, author then makes immediate use of them for the calculation of the vertical movements on the upper boundary H of the friction layer by means of the formula

$$\omega_H = \frac{1}{2\omega_z\rho_H}\left(\frac{\partial\tau_{0y}}{dx} - \frac{\partial\tau_{0x}}{\partial y}\right) + \frac{\operatorname{ctg}\varphi}{R}\left(u_N H + \frac{\tau_{0E}}{2\omega_z\rho_H}\right)$$

($2\omega_z$ is Coriolis' parameter, ρ the consistency (density), τ_{0x}, τ_{0y} the components of the turbulent tangential pressure when $z = 0$, R the distance to the center of the earth, u_N the mean meridional component of the geostrophic wind [from the earth to height z], τ_{0E} the projection of the tangential pressure on the tangent to the sphere of the latitude). Simplified formulas are put forward for the calculation of the mean vertical velocities for some region.

V. P. Sadokov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4810. Hill, H. T., Inspection techniques applied to the metrology of aerodynamic models, *AGARD Rep.* 24, 9 pp. + 16 figs., Feb. 1956.

4811. Rush, C. K., and Wardlaw, R. L., Icing measurements with a single rotating cylinder, *Nat. aero. Establ. Canad.* LR 206, 8 pp. + 13 figs., Sept. 1957.

A method is presented for calculating the rate of icing and cloud water content from the ice accretion on a single rotating cylinder. The effect of catch efficiency and blow-off are discussed. Typical charts are presented for use with a particular size of cylinder. The method is based on the theory that a small object moving relatively to a cloud of supercooled droplets will catch most of the droplets in the swept volume of air, except those that are diverted by aerodynamic forces. This divergence is termed "catch efficiency," and it is a function of several variables, such as drop size, object shape and size, and relative velocity. Equations are developed for the rate of icing (inch per hour), and for the water content of the cloud. In the experiments, beryllium copper tubing of 0.10-in. diam and 2-in. length was used. Charts are given for the catch efficiency for small and large droplets as a function of relative speed, droplet diameter, and cylinder diameter.

K. J. DeJuhasz, Germany

Lubrication; Bearings; Wear

(See also Revs. 4364, 4551)

4812. Tyabin, N. V., Shklyar, L. A., Mesikhin, E. P., and Vinogradov, G. V., Flow of a consistent lubricant on a rotating disk under the action of centrifugal forces (in Russian), *Trudi Kazansk. khim.-tekhnol. in-ta* 18, 123–141, 1954; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6689.

Examination of the radial flow of a lubricant on a rotating disk. The limiting stress for displacement is considered in boundary conditions. With the aid of a number of assumptions an approximate formula for velocity and second discharge is obtained. Results are given of the tests on the measurements of the nucleus of form retention and certain results of processing of the film frames.

The kinematic picture of motion which was assumed by the author is incorrect. If the dependence of v_r on z is considered, it is necessary to take $v_z \pm 0$ since otherwise a contradiction is obtained. In fact, the equation

$$\frac{\omega^2 r}{3} + \frac{v^2}{r} + \frac{\eta p l}{\rho}\frac{d^2 v}{dz^2} = 0 \qquad [5]$$

has no integral of the form

$$v = \frac{U(z)}{r} \qquad [*]$$

But if v_z is taken to be zero, the equation of nonseparation is reduced to the form

$$\frac{\partial v}{\partial r} + \frac{v}{r} = 0$$

whence (*) follows.

N. A. Slezkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4813. Deacon, R. F., and Goodman, J. F., Lubrication by lamellar solids, *Proc. roy. Soc. Lond.* (*A*) **243,** 1235, 464–482, Feb. 1958.

An experimental study has been made of the friction properties of graphite, molybdenum disulphide, boron nitride and talc. The formation of surface layers of the lamellar solids on platinum, and the friction of these layers at elevated temperatures in air have been examined.

There is evidence that the frictional behavior of the solids is dominated by the forces acting between separate crystallites, cleavage of individual crystallites being of secondary importance. The structure of the lamellar solids gives rise to plate-like crystallites, and a large proportion of the surface area is composed of faces with relatively low surface energy, with a small proportion of high-energy edge surface. The edges can react with gases to give a surface of relatively low surface energy, and the adhesion between the crystallites is then small, giving the solids low friction properties. In general, the removal of adsorbed gases increases the adhesion between the crystallites (particularly at the edges) so that the friction increases. This is observed for the removal of physically adsorbed volatiles from the partly ionic boron nitride and talc, and for the removal of the chemically bound carbon oxides from graphite. Molybdenum disulphide behaves differently, for with this solid the presence of adsorbed water promotes hydrogen bonding between the crystallites and thereby increases the adhesion between them.

Other workers have shown that the friction of outgassed graphite *in vacuo* decreases reversibly at high temperatures. A similar behavior has been shown to occur for boron nitride in air at temperatures below that at which it oxidizes rapidly, and suggests its use as a high temperature lubricant. The decrease in friction is caused by a gradual weakening of the intercrystallite bonding as the temperature is increased. Small quantities of bulk impurities can have a large influence on the intercrystallite bonding. It is believed that the impurity responsible in the case of boron nitride is boric oxide, because it melts at a temperature close to that at which the reversible decrease in friction occurs. Thermogravimetric analysis has been used to show that when the materials undergo a chemical change such as rapid oxidation they no longer give a low friction even when present in excess on the surface.

Electron diffraction studies show that on rubbing in air the lamellar solids tend to form oriented layers on the metal surface, so that the plate-like crystallites lie flat. The orientation does

not cause the low friction, but the low adhesion between the crystallites allows them to become oriented in their most favorable position, and independently causes the friction to be low. Reflexion electron micrographs show that the lubricant is occluded within crevices in the surface. The micrographs of the tracks formed during lubricated sliding show that the metal is deformed plastically, but that failure occurs mainly or entirely within the lubricant. An important factor in the formation of satisfactory lubricant layers appears to be the hardness of the lubricant relative to that of the metals, as the lamellar solid may protect the metal by becoming embedded in the surface.

From authors' summary

4814. Constantinescu, V. N., On unsteady lubrication (in French), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 2, 1957.

Paper discusses the general pressure equation for unsteady régimes (variable velocities and forces). To obtain pressure distribution the solution p is decomposed into two parts; the first one $\bar{p}$, whose determination is performed in the same manner as for steady régimes and the second one $\overline{\bar{p}}$, which may be obtained in an analogous manner.

These considerations are applied to determine pressure distributions for slider bearings, journal bearings with no radial clearance and spherical bearings, obtaining thereby rigorous solutions for the pressure equation.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4815. Tipei, N., and Nica, A., On boundary conditions and oil flow in complete journal bearings (in French), *Acad. Repub. Pop. Romane, Rev. Mêcan. appl.* **2,** 1957.

Paper presents hypotheses concerning boundary conditions, and results are compared with experimental data obtained by authors as well as those obtained by others in case of load-carrying film extent, the friction-generating film extent, and oil flow.

A new expression for oil flow is presented, and the influence of some parameters is emphasized.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

4816. Baudry, J., Contribution to the study of lubricated friction (in French), *Rev. Inst. fr. Petrole et Ann. Comb. liq.* **12,** 9, 951-994, Sept. 1957.

Author reports on many results obtained in an experimental bearing with fluid, semifluid, and "extreme pressure" lubrication. In semifluid lubrication, effects of load, viscosity, velocity, condition of surfaces, oil nature have been investigated and plotted in graphs; conditions of thermal equilibrium of oil are also considered and some tests about multigrade oils are reported.

To explain friction variations in (1) fluid, (2) semifluid, and (3) extreme-pressure lubrication, a simplified theory is proposed, based on several rather dubious hypotheses, leading to a coefficient f of friction depending, in semifluid and extreme-pressure lubrication, upon three parameters (thickness of adhering oil layer, average height of asperities, a coefficient defining the form of the profile). Experimental results, when interpreted by the final formulas of this theory, give very similar values for these parameters. In the second part, measures of mechanical losses, mainly due to friction, have been made in a running 11-hp motor, comparing indicated power (gas pressures were registered by a new stroboscopic manograph giving discontinuous values corresponding to single crankpin angles) with brake power at full, 3/4, 1/2 load and several temperatures of cooling water. Loss diminution with increasing temperature of water showed that fluid or semifluid lubrication took place.

Reviewer believes that reported experimental results can give several interesting indications, mainly about semifluid friction, though multiplicity and complexity of involved factors leave some uncertainties about their theoretical interpretation.

R. Giovannozzi, Italy

4817. Osterle, J. F., and Hughes, W. F., High speed effects in pneumodynamic journal bearing lubrication, *Appl. sci. Res. (A)* **7,** 2/3, 89-99, 1958.

Reynolds equation, including effect of fluid inertia, is solved for conditions of high speed and low load in gas-lubricated journal bearings. Perfect gas laws and isothermal conditions are assumed; constant viscosity and density varies with pressure; approximation used involves averaging of inertia over the film thickness. Equations are solved numerically by IBM 650 computer. Pressure distribution curves for speeds up to 200,00 rpm are given for different values of eccentricity ratio. Results show inertia effects can be significant in laminar regime. Error in load capacity depends more on speed than eccentricity ratio, amounting to 11% at 200,000 rpm. At low speeds, inertia effect is negligible.

C. F. Kettleborough, New Zealand

4818. Jakobsson, B., and Floberg, L., The finite journal bearing, considering vaporization, Rep. 3 (in English), *Trans. Chalmers Univ. Technol.* no. 190, 116 pp. + 13 ref., 1957.

For a 360° finite journal bearing without oil grooves but completely submerged in oil, a solution of Reynolds equation with regard to the boundary conditions $p = p_0$ at $z = \pm b/2$ and $p(-\pi) = p(\pi)$ yields a pressure distribution antisymmetrical with respect to the angle of minimum film thickness and symmetrical with respect to the middle cross section $z = 0$. But if the pressure does not everywhere exceed the vapor pressure of the oil, or in the case of oils having dissolved air or other gases the pressure at which these gases are expelled, the calculation is no longer valid, because a vapor region is formed and therefore other boundary conditions are to be satisfied. The vapor region possesses a constant pressure p_{vap}, begins at angles $\varphi^*(z)$, at which the pressure curve runs into the value p_{vap} with vanishing pressure derivatives $\partial p/\partial\varphi$ and $\partial p/\partial z$, and ends where the film thickness h satisfies the equation $h^* = h - h^3/6\eta\, U \cdot [(\partial p/r\partial\varphi)^2 + (\partial p/\partial z)^2]/\partial p/r\partial\varphi$ (h^* = film thickness at the angle $\varphi^*(z)$). These boundary conditions are derived from the continuity principle. In order to get the pressure distribution, Reynolds equation must be solved with respect to these conditions. A solution can be obtained in the following manner: Assume a vapor region. Determine the pressure distribution by a relaxation method, and check the boundary conditions. From this check a better boundary for the vapor region can be assumed. The new boundary gives a new pressure distribution. This gives a new check, and so on, until a satisfactory result is reached. Thus pressure distribution and load capacity can be determined. In order to calculate friction torque and power loss, oil-film friction also in the vapor region must be taken into account. Because the pressure derivatives vanish in the vapor region, a linear velocity distribution is formed everywhere, and, on the strength of continuity, the oil film is split up into strips with a width which decreases with increasing thickness of the gap.

Authors compare the results of the theoretical calculations with experiments and state a good agreement.

After that, the 180° bearing with minimum film thickness at the trailing edge with the boundary conditions $p = 0$ at $z = \pm b/2$ and at $\varphi = 0$ and $\varphi = \pi$ is treated.

Authors then represent and discuss calculations from Cameron-Wood and Sassenfeld-Walther. These authors solved the Reynolds equation paying attention to the boundary conditions $p = 0$ at $z = \pm b/2$ and at maximum film thickness and $p = 0$ and $\partial p/\partial\varphi = 0$ at the beginning of the vapor region. The results apply to the 360° bearing with an oil groove at the maximum film thickness and a vapor region at atmospheric pressure.

Moreover Sassenfeld-Walther dealt with the solution of Reynolds equation for the boundary conditions $p = 0$ at $z = \pm b/2$ and at $\varphi = -(90° + \beta)$, (β = angle between load-line and centerline) and $p = 0$

and $\partial p/\partial \varphi = 0$ at the beginning of the vapor region. The results are applicable to the 180° atmospheric pressure and to the 360° bearing with an oil groove 90° before the load-line and a vapor region at atmospheric pressure. Both cases differ from each other only in respect to friction torque and power loss. Sassenfeld-Walther's determinations of these quantities are not correct, as they assume that there is only oil in the vapor region of the 360° bearing and only air in the vapor region of the 180° bearing. Therefore these quantities were calculated once more by the authors of the present paper. U. Rost, Germany

4819. Sternlicht, B., and Shock, H. J., Numerical solution of Reynolds' equation for sector thrust bearings, *Lubrication Engng.* **13,** 8, 459–463, Aug. 1957.

An IBM 650 digital computer was used for solutions involving both constant viscosity and an experimentally determined varying viscosity. Reviewer believes the nonuniform viscosity solutions warrant more emphasis than received here, both because they are of practical interest and because they are indicative of the possible advantages of the method used.

E. J. McBride, USA

4820. Kogan, Ya. J., Bogdanow, O. J., and Jantowski, Je. J., New method for measuring thickness of oil-film in bearings, *Deutsche Elektrotech.* **11,** 2, 81–83, 1957 (*E.T.D.*, 1957, p. 1062–1063).

Measurement of the thickness of the oil-film by induction enables permanent control of large bearings, with a limited amount of apparatus. *Courtesy European Technical Digests*

4821. Rozeanu, L., and Preotescu, O., A qualitative separation of wear factors, *Acad. Repub. Pop. Romane, Rev. Mécan. appl.* **2,** 1, 1957. (See also *Engineers' Digest* (*Lond.*) **19,** 3, 102–105, Mar. 1958.)

Authors separate four fundamental types of wear: adhesive wear, far less dangerous than predicted by theory; abrasive wear, a severe accidental type which can be partially controlled and almost completely eliminated; corrosive wear, of varying importance, which can be controlled and even used in the fight against wear; and lastly fatigue wear, an unavoidable and steadily growing type of wear. The time factor defines three chronological sets of wear conditions; initial conditions (running in) which appear to be the complement of production technology for correcting local faults, normal conditions which result from complex action of statistically normal factors in the friction process, and final conditions which bring up the deleterious factors which have invisibly acted upon the previously indicated wear phases.

Staff, Revue de Mecanique Appliquee
Acad. Repub. Pop. Romane, Rumania

Books Received for Review

ALPERIN, M., STERN, M., and WOOSTER, H., Vistas in astronautics, New York, Pergamon Press, 1958, xxii + 330 pp. $15.00.

ARROW, K. J., KARLIN, S., and SCARF, H., Studies in the mathematical theory of inventory and production, Stanford, Calif., Stanford University Press, 1958, vii + 340 pp. $8.75.

BARRERE, M., JAUMOTTE, A., FRAEIJS DE VEUBEKE, B., and VANDENKERCKHOVE, J., La propulsion par fusees, Paris, Dunod, 1957, xii + 389 pp.

DAVIES, M., and VERHULST, M., Edited by, Operational research in practice, New York, Pergamon Press, 1958, ix + 201 pp. 84s.

DUB, O., Hydrologia, hydrografia, hydrometria, Bratislava, Slovenske Vydavatel'stvo Technickej Literatury, 1957, 485 pp. Kcs 41,30.

ECKMAN, D. P., Automatic process control, New York, John Wiley & Sons, Inc., 1958, viii + 368 pp. $9.00.

ENGLISCH, C., Kolbenringe, Vol. I, Wien, Springer-Verlag, 1958, viii + 457 pp. $18.55.

FLEMMING, H. W., Wuesten Deiche und Turbinen, Berlin, Musterschmidt-Verlag-Gottingen, 1957, 430 pp. DM 28.60.

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